DESIGN edition

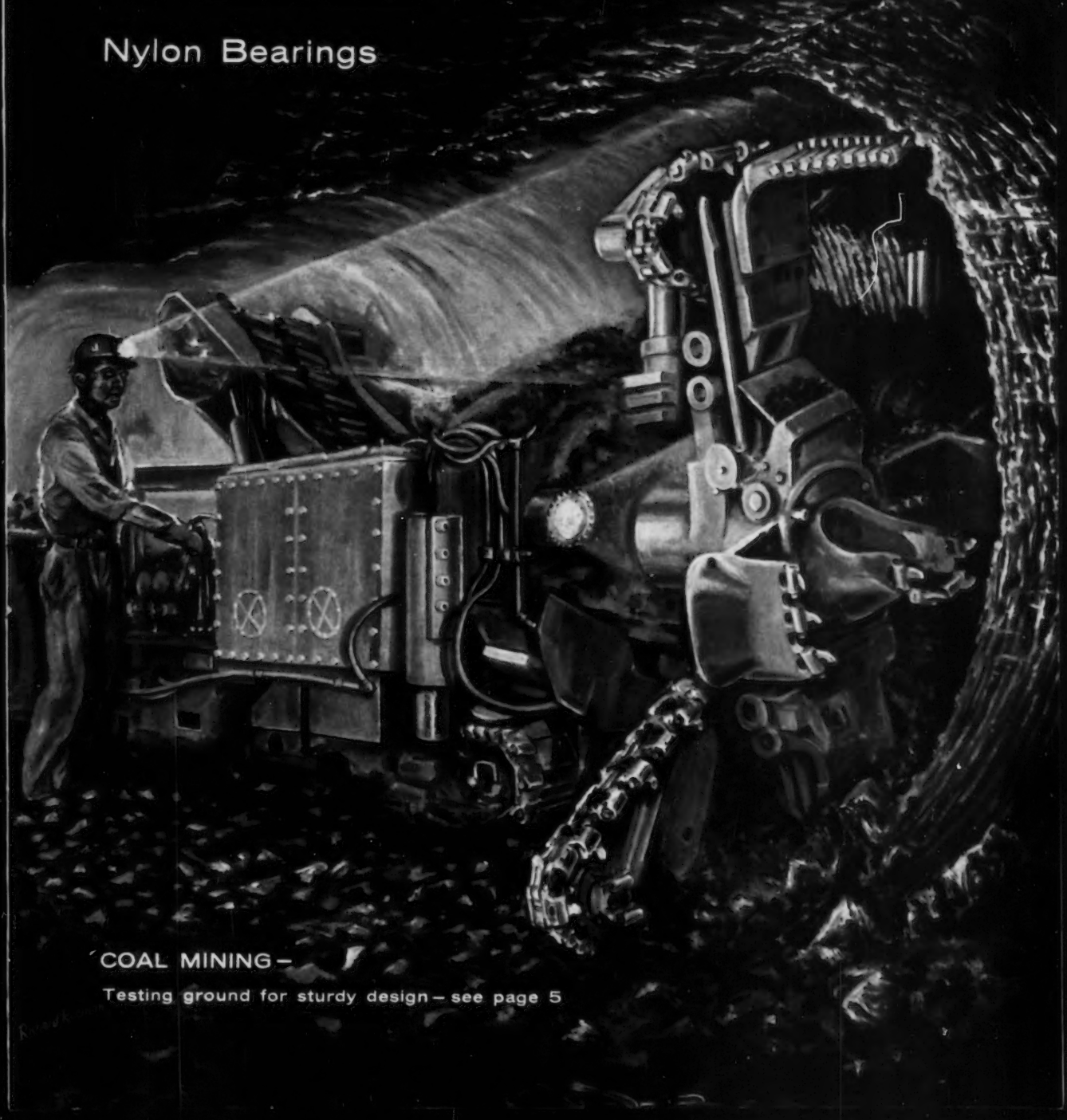
MARCH 3, 1958 PRICE 50 CENTS

Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN RESEARCH AND DEVELOPMENT

Starting High-inertia Loads

Nylon Bearings



COAL MINING—

Testing ground for sturdy design—see page 5

Sirvene impeller blades bend 90° at 1750 r.p.m.

– but never break, never take a "set"

Hypro Engineering, manufacturer of pumps for farm, home and industrial use, needed a better transfer pump impeller. When they came to C/R Sirvene they asked, "Can *you* compound and mold an impeller that will tolerate extreme blade deflection 1750 times a minute and resist 'setting' during long inoperative periods, and still meet our standards for service life?" Compounding to achieve resistance up to 160°F. over a wide range of mild acids, brines, detergents, oils and liquid fertilizers was relatively simple. The real problem was molding. Sirvene engineers knew that conventional methods would not assure the required flex strength. They also knew the molding technique that *would*—and went to work. Test runs on this Sirvene impeller proved out the technique and the part was approved for production. "That was five years ago," states Mr. Cook, President of Hypro Engineering, "and we haven't had an impeller problem since. When you need a flexible molded part, call in C/R Sirvene engineers. Their experience and facilities are unmatched."

Write for your copy of the new booklet, Sirvene.

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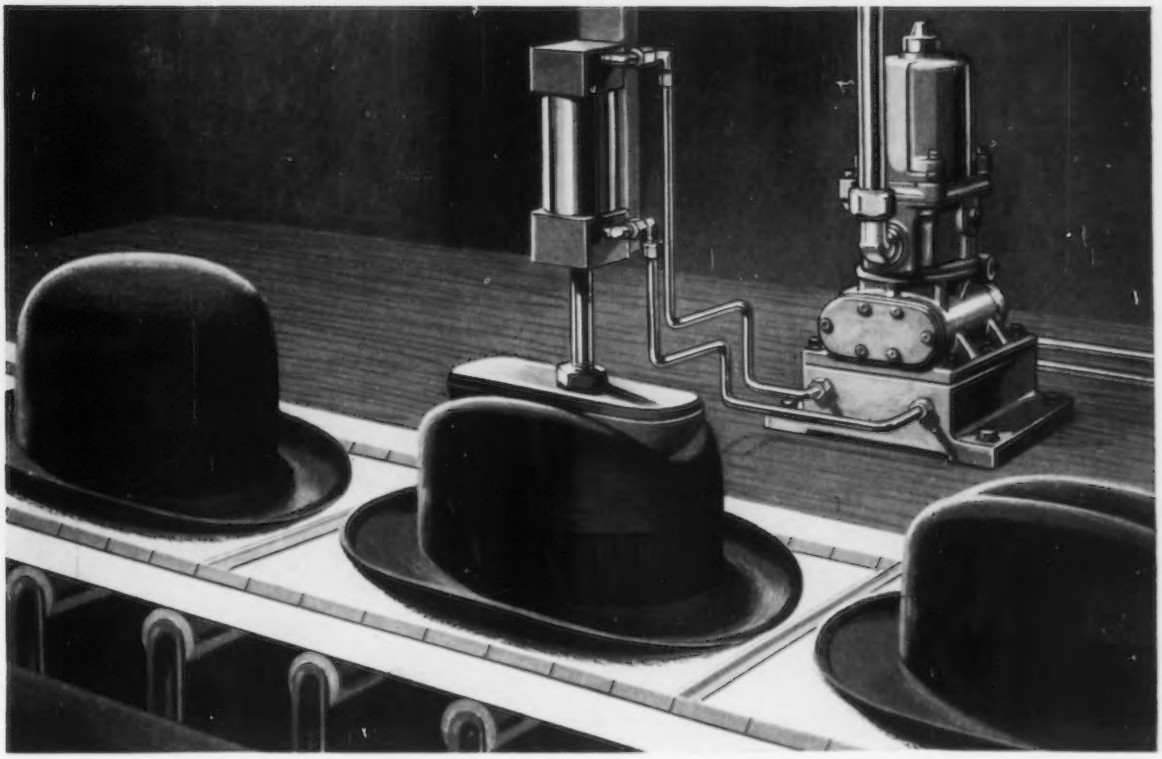
What? A Homburg Dimpler!

Unlikely?...Yes, but...



Unlikely? Yes—most men will continue to give the top of their pet fedora a "just-right" push of the fist when they buy it back from the hat check girl. But this little flight into fancy does give us a chance to show a cylinder with a split personality . . . able to advance softly, then retreat quickly to get the next hat into position without waste of time. It's made possible with a Ross 4-way, 5-port valve that provides a *different* pressure for each side of the cylinder.

Maybe you have a serious problem that the Ross 4-way, 5-port valve can solve

The same idea of cylinder advance and retreat is put to very real and valuable use in many machines today. Perhaps you, too, have an application where *one* valve controlling *two* pressures will cut production costs. Contact your nearby Ross Service Engineer or write us for details on the 4-way, 5-port valve.

Combining engineering with ingenuity for better air control

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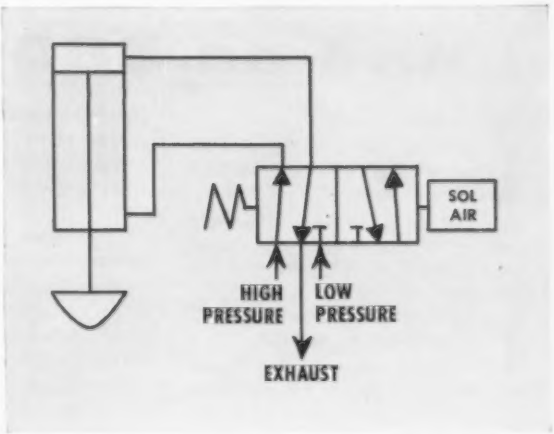

1. Solenoid is energized, creaser descends slowly.
2. Solenoid is de-energized, creaser rises quickly.

Relieves traffic congestion. To handle the ten million cars a year which now funnel onto the 3-lane Carquinez Bridge, (right) the State of California is building this second bridge connecting the San Francisco Bay area and the Sacramento Valley. Use of nickel-containing USS "T-1" Steel in critical truss members has simplified design...reduced unnecessary weight...saved money.

A tale of two bridges ...and an $800,000 saving

Twins? *Almost.*

But there are two differences. The span on the right is 30 years old. Her sister is brand new.

Another big difference is in their construction materials. The most highly stressed truss members of the new bridge are USS "T-1" Steel . . . a high yield strength constructional alloy steel containing nickel.

"T-1"®, produced by United States Steel Corporation, has nearly three times the yield strength of structural carbon steel. It is at least four times as resistant to atmospheric corrosion. And it can be welded with relative ease.

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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

MARCH 3, 1958 Vol. 29, No. 9

New Nylon Clads Sleeve Bearings 52... D. L. Penney and F. J. Bockhoff, Penn College
Here's another practical application for moisture-resistant nylon-11. Fluidizing process coats it on metal sleeve bearings.

Linear Programming Can Be Easy Math 55... G. F. Hadley, Massachusetts Institute of Technology
Author shows how the answer can be charted—just with pencil, paper and simple arithmetic—when the problem is a transport type (which needn't involve actual transportation at all).

Which Finish for Zinc Die Castings* 59... Ray Stricklen, Allied Research Products
For quality plus economy, suit the finish to the part being made—a guide to mechanical, chemical, plating, painting methods.

Design Features in New Products 62... Tape programs assembly; lathe cuts spirals; redesigned automation speeds production; test-ring rates casting machine; modified engine compresses air; fork lift works like an elephant.

31 Ways to Make a Cam* 67... H. A. Rothbart, City College of New York
Following up his textbook on cams, the author has compiled here a complete list of manufacturing methods, along with probable accuracy obtainable from each. Photo sequence illustrates 11 leading methods.

Small Induction Motors 72... I. E. Ross and R. W. Groot, General Electric Co.
Improved design is putting them into the world of business machines where they are taking work away from the series-wound types.

SPECIAL REPORT

Controlled Acceleration Devices* 75... J. R. Eastman, Sterling Electric Motors
Here are 7 answers when the problem is teaming together a high-acceleration power source and a machine that must start at a slower rate. Each method is appraised in text and basic-data chart, with special advantages weighted against inherent limitations.

DESIGN FILE

Fastener Checklist 82...
When you wonder if any points covering design or selection have been missed, consult this question-answer review.

How to Write "Instructions" 85... H. E. French, Sanborn Co.
A streamlined outline on how to write complete technical information about a component or process—and write it fast.

DEPARTMENTS

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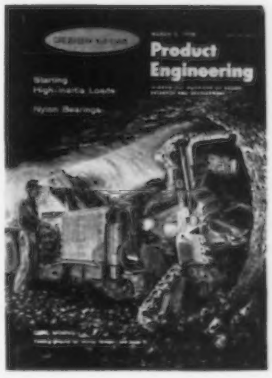
Interesting to Note . . .

Color for Coal



Coal mining has long been one of the most hazardous and laborious of occupations—so much so that young men have been unwilling to enter it. In recent years, mines have met the labor and cost problems by such techniques as strip and automatic mining. Although the bituminous labor force has declined from 462,000 to 200,000 in the last 15 years, output per man has more than doubled. The major credit is due to continuous miners like that pictured on our cover. This one is made by Goodman Mfg. Co., Chicago, and incorporates design elements of surprising ingenuity. Twin rotating units, geared together and equipped with bit-filled cutting arms, a center pilot, and a center core burster, cut and break out the coal. A cutter chain at top and bottom cuts free the center wedges of coal and widens the path at the bottom on each side. It can also cut a wide flat top for bracing if desired. Coal drops down to the bottom, is pushed up to the center throat of the conveyor by deflectors on the rotating arms. The machine cuts and loads up to 6 tons of coal per hour, can cut at 60 in. per minute. Arms rotate at 15½ rpm, can be tilted to follow a seam. Control is hydraulic.

We at PRODUCT ENGINEERING planned a mining cover a year ago. But 4-color pictures are impractical in a coal mine. The prevailing color is black. A bright-yellow machine becomes coated with coal dust in a few hours. Flash or floodlights for photography are lost against the black. We tried pictures, but they had no color. So we asked Art Director Dick Rooman to paint the scene for us. It is technically accurate, and the color is pleasing.

Zinc Goes Modern

Several years before the birth of Christ, the Greek historian and geographer, Strabo, wrote of an ore "which when burned becomes iron, and when heated in furnaces with a certain earth distills 'mock silver'." This was perhaps the earliest writing about the element zinc. Evidence that zinc was known before Strabo's writings are numerous—Roman brass coins, early Chinese mirrors, zinc-filled bracelets found in the ruins of Cameros which was destroyed around 500 B.C.

Many years after early scientists and alchemists had worked with the metal. Sir Humphry Davy, then with the British Navy, connected strips of zinc to the copper sheathing of wooden-hulled ships.

(Continued on page 7)

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No Creeping Cylinders	Leakproof closure. (No internal port to port leakage.)	Maintained through lapping action of each operation.

Ask for bulletin 2801-7.

Foot operated models with or without spring return to reverse or to center are $24.50 list for the ¼" and $25.50 for the ⅜" valve less quantity discounts.

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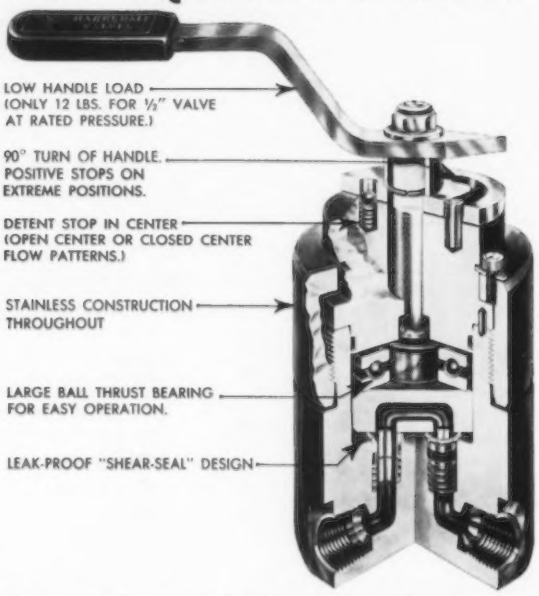
FOR LIQUIDS OR GASES


LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
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LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

This highly successful principle of extreme pressure control is fully described in "Shear-Seal" bulletin BVM-2.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

This was the first time zinc was used for cathodic protection. Since, it has found extensive application not only in the protection of ship hulls but in galvanizing and die castings. The Edsel, for example, wears 48 lb of zinc per car in trim alone. To coat zinc can sometimes be an expensive, difficult operation. The article on page 59 shows how it can be done inexpensively.

Ants on the Move

We have all, at some time, watched an ant wending his way along a path or carrying a crumb of bread over a picnic blanket. We have seldom given the little fellow more than a passing thought. Who would ever think that those few uninvited ants at your picnic may represent a scouting party for the whole colony?

Although the problem involved in transporting that bread crumb may not be as involved as the problems discussed on page 55, for the ant it represents carrying nearly twice his own weight.

Trails are established as soon as one of their scouts finds your picnic blanket. Somehow, the ant becomes excited, lowers its abdomen and through gland openings leaves a distinct odor trail back to the home base. Before long the colony moves in and shares in your lunch.

The network of communications developed by ants is still unknown to entomologists. They can transmit messages and also have the ability to handle a situation like soldiers on maneuvers. The Army ants not only have scouts but break their forces into divisions. Behind the main forces move supplies, reinforcements and even a burial crew.

There is one species of ant, the Ecitons, who have no transportation problem. They move in swarms, eating as they go. Their logistics are simple—eat everything edible, then gather in a swarm for the night; comes the dawn, keep on eating.

Roar, Lion, Roar

At a recent press gathering to usher in the '58 Motor Boat Show, we met a fellow who has found an amazing application for his tape recorder. He told us that he keeps a hi-fi speaker locked in his office closet, then when an unwanted salesman enters, the executive presses the start button on his recorder. From the closet comes first a shuffling, then the sound of a lion attempting to exercise his claws on the closet door. While the salesman breaks out in a cold sweat, our friend calmly asks him to please open the closet door because Bruno wants his lunch. At this point, a terrifying roar shakes the place and the salesman makes a hurried exit.

There are over a thousand applications for magnetic tapes. All provide a simplified way to record data—be it lion cries or classical music. Another method of recording is the punched tape. Here again data can be recorded and stored for future use. On page 66, the design story of a punched tape that programs assembly operations is presented.

The taping of animal sounds is mushrooming. Since birds, animals, insects and even fishes all communicate by sound, the zoologist's job now requires a knowledge of tape recorders. In fact, a recent conference at Pennsylvania State University discussed that problem. The result—formation of the International Committee on Biological Acoustics.

And a Mighty Nation Fell

As science advances at its current rapid rate, it may be time to pause and inquire whether man's ability to communicate with man has been able to maintain the pace. It so happens that the language of most sciences is universal and precise—mathematical symbolism. That is fortunate. But the art of conveying concepts by word symbols is still in the dark ages.

About 300 B.C., Darius III, King of Persia, faced a serious dilemma. Outside the city walls of Gaugamela were the armies of Alexander the Great. Within, King Darius had to decide between surrender or battle. If he could defeat the legions of Alexander he would rise to the pinnacle of an empire; defeat meant death. As was the custom, the king sought advice from the court soothsayer. Darius asked, "If I go to battle, will I defeat Alexander?" The sage's answer showed the fallibility of the language, yet was true. "When Darius meets Alexander, a mighty nation will fall." To Darius, that "mighty nation" could only mean the empire of Alexander—Italy, Africa, Syria and Asia Minor. The battle was history. Alexander added the great Persian nation to his domain and kept right on marching.

Interpreting the written word is as confusing today as it has always been. How many international squabbles have ensued because one word was misunderstood? It is just as important to learn how to issue orders, reports and directives. The article on page 85 puts forth a few hints that may make the problem of conveying ideas a little easier.

—Benedict A. Leerburger Jr.

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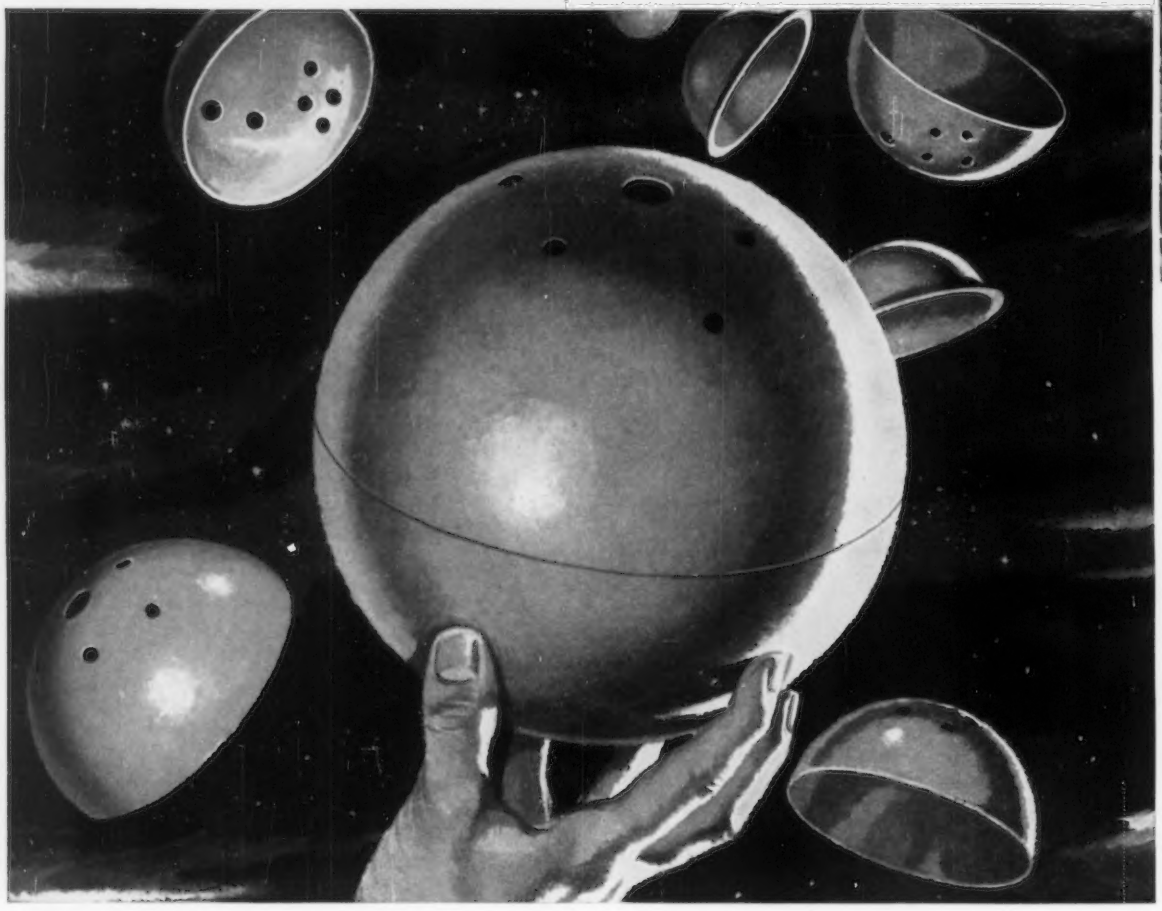

TITANIUM HEMISPHERES ARE STRONG, LIGHTWEIGHT, DEFY CORROSION BELOW —150°C. They are used in highly specialized aeronautical applications calling for high strength, light weight, and resistance to the severe corrosive action of liquefied gases at severe sub-zero temperatures.

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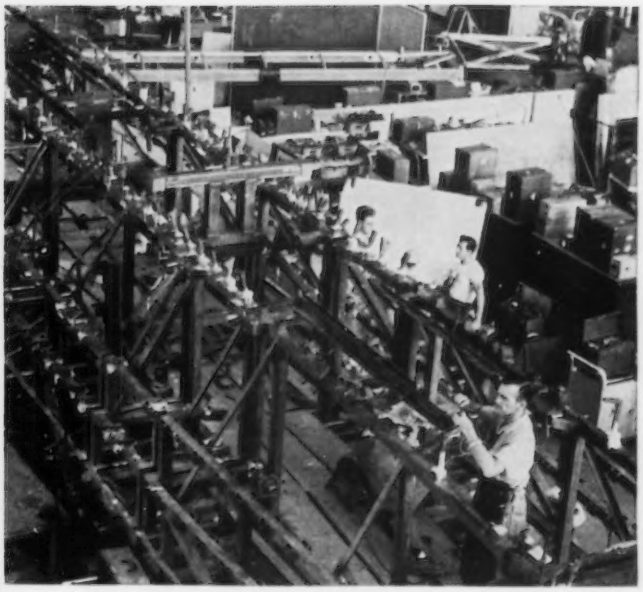
2. This exceptionally high-strength property enables this product to withstand burst pressures in excess of 2,000 lbs. psi.

3. Titanium's extremely high corrosion-resistant properties defy the corrosive action to which the units are constantly exposed.

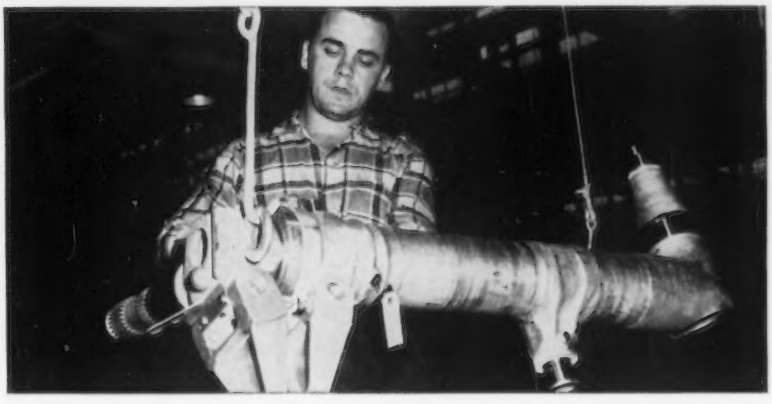
The entire fabricating operation is performed without difficulty and with little change in procedure as compared to other materials. Fabricating steps include drawing, trimming, piercing, extruding, and welding.

Does this application of Republic Titanium generate an idea for your product that needs to be strong, lightweight and corrosion-resistant? Republic Metallurgists are ready to help you apply titanium's advantages now. This service is confidential and without obligation. Mail coupon today for more information.



STRENGTH AND SAFETY IN MISSILE jig and fixture assemblies is provided by 4" x 4" square carbon steel mechanical tubing. It is used because of its greater strength-to-weight ratio in structural applications. Elimination of accident-causing sharp edges adds to the safety margin. Republic Steel and Tubes Engineers will help you design ELECTRUNITE Mechanical Tubing into your product to speed production, cut costs, save weight, improve product performance. Mail coupon.

TOUGHNESS, HIGH STRENGTH-TO-WEIGHT RATIO, resistance to heat and corrosion are advantages of ENDURO Stainless Steel designed into both structural and operating parts of supersonic Convair F-102A. ENDURO is made for flight in both military and civilian aircraft. Its outstanding combination of properties offers almost unlimited freedom in design and application. Republic will help you apply it to best advantage. Write us.



MAXIMUM RESISTANCE TO FATIGUE, strength and toughness are provided by Republic Alloy Steel in landing-gear struts of North American's F-100. The struts are made by Bendix Aviation Corporation. Bendix and Republic metallurgists, working closely with North American engineers, developed a new grade of alloy steel to meet exacting requirements of the strut's inner and outer cylinders. It has a strength range of 220,000—240,000 psi and maintains this great strength at wide temperature extremes. Republic Alloy Metallurgists are available to help with your projects.

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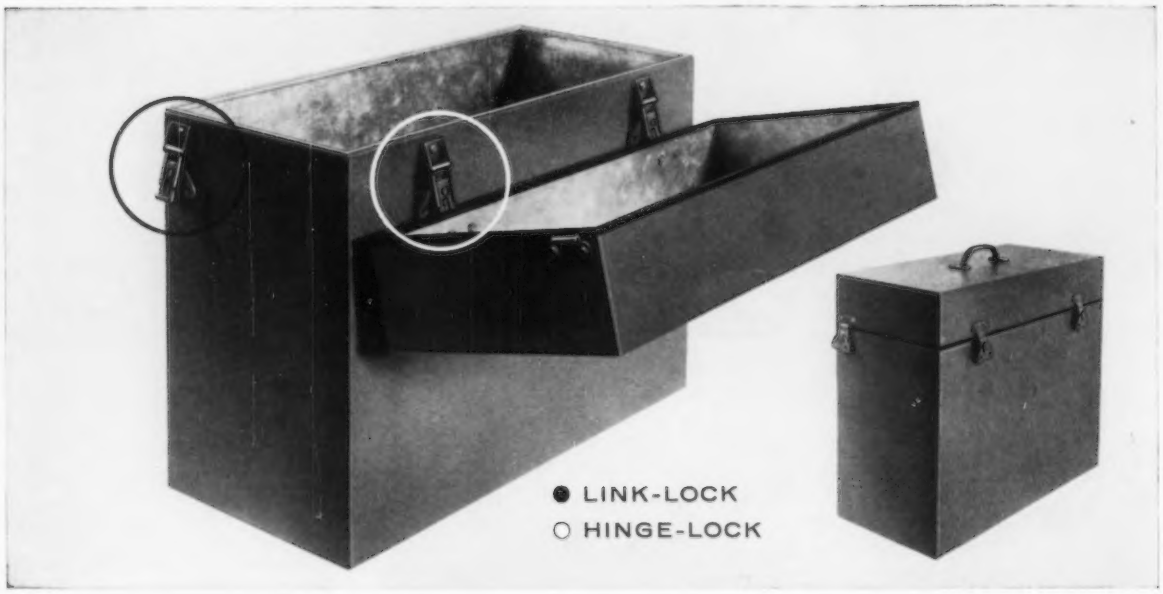


No. 3 LINK-LOCK

No. 3 HINGE-LOCK

Two HINGE-LOCK and two LINK-LOCK Fasteners provide all-around sealing pressure on this container manufactured for the U.S. Navy by the Bonded Structures Division, Swedlow Plastics Company.

The new Simmons HINGE-LOCK, used in combination with LINK-LOCK, provides an even, pressure-tight seal on equipment containers and transit cases with hinged covers. A half-turn applies pressure to both types of fasteners. When pressure is released HINGE-LOCK becomes a free-operating hinge, and LINK-LOCK disengages to permit opening.

Originally developed by Simmons Fastener Corp. for the Engineering Department of Swedlow Plastics Company, Bonded Structures Division, HINGE-LOCK is similar in principle and appearance to LINK-LOCK. Both are available in light and medium duty sizes as matched hardware. LINK-LOCK is also available in a higher-capacity, heavy-duty size.

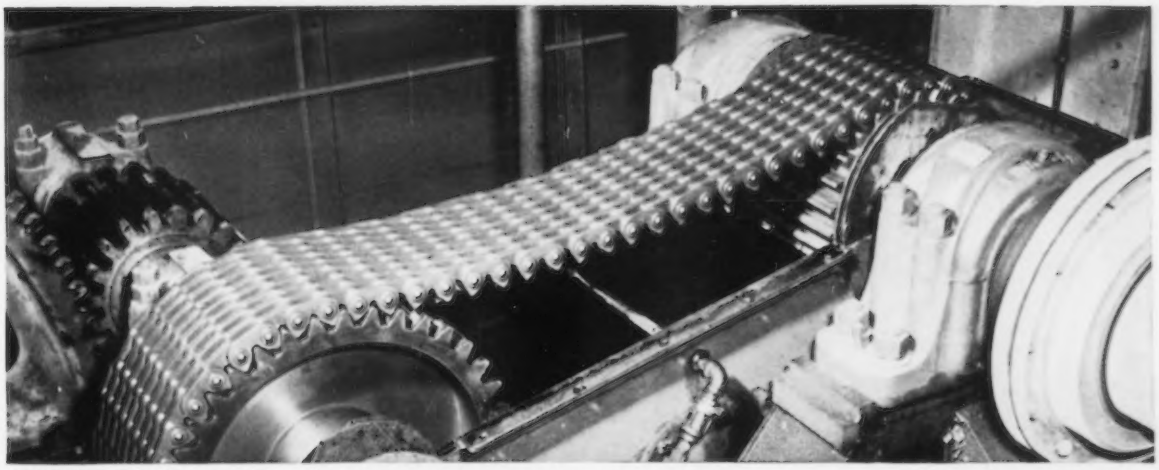
SEND TODAY for complete data, including dimensions, capacities. Engineering service is available... Outline your requirements. Samples on request.

Visit us at Booth 1020, DESIGN ENGINEERING SHOW
International Amphitheatre, Chicago, April 14-17, 1958

See our 8 page catalog in Sweet's 1958 Product Design File

SIMMONS FASTENER CORPORATION 1751 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • LINK-LOCK • HINGE-LOCK • ROTO-LOCK • DUAL-LOCK



HIGH SPEED. Traveling at speeds as high as 5000 fpm, silent chain drives readily accommodate the extreme peak loads without losing their better-than-98% efficiency.

How LINK-BELT silent chain drives survive industry's roughest requirements

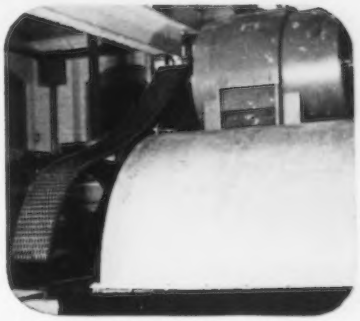
Would your drives do as well?

On applications like these and scores more, no other type of drive is the equal of Link-Belt silent chain. Ask your nearby Link-Belt office for a copy of comprehensive 88-page Data Book No. 2425.

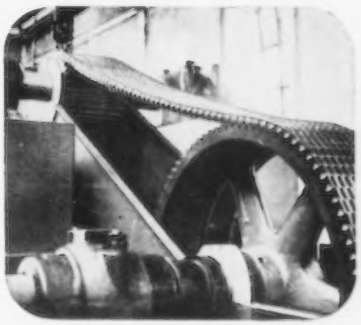
LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,679-A

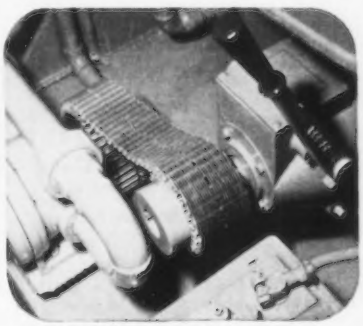


LARGE OR SMALL HP. On a 300 hp drive like this or at fractional hp, silent chain is always lower in ultimate cost.

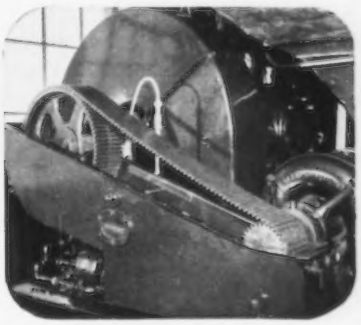


LARGE RATIOS. Link-Belt silent chain operates efficiently on extremely short centers at ratios as high as 10-to-1.

ADVERSE OPERATING CONDITIONS. Heat, humidity and cold have little effect on Link-Belt silent chain drive performance.



LIMITED SPACE. Easy to assemble in close quarters, Link-Belt silent chain permits built-in drives, compact housings.



LONG LIFE. This drive is 16 years old and still going strong. Not unusual—many others have lasted twice that long.

KLIXON
Protectors prevent motor burnouts in famous
WASTE KING
Dishwashers
"From the start KLIXON Motor Protectors have been a part of our never ending effort to make the Waste King dishwasher the best."
Automatic Dishwasher
Waste King

That's the comment of John A. Fay, Project Engineer, Dishwasher Section of the Waste King Corporation, manufacturers of the famous Waste King dishwasher.

Waste King is another in the growing list of famous appliance and equipment manufacturers who look to KLIXON Protectors to assure trouble free motor operation under any overload condition.

Manufacturers learned long ago of the advantage of using KLIXON protected motors in their motor driven products. You, too, can keep motors in your equipment or products working dependably by merely specifying KLIXON Protectors in your motors when you order them.

You'll find they reduce maintenance costs, service calls, repairs and replacements. The additional cost is minor — the benefits exceptionally worth while both for you and your customers.

AUTOMATIC RESET PROTECTOR

Now there's something NEW

In addition to the famous KLIXON Protector for single-phase motors, you can now get full protection engineered into your 3-phase motors with a single, built-in KLIXON Protector. For details write for Bulletin MOPR 1.

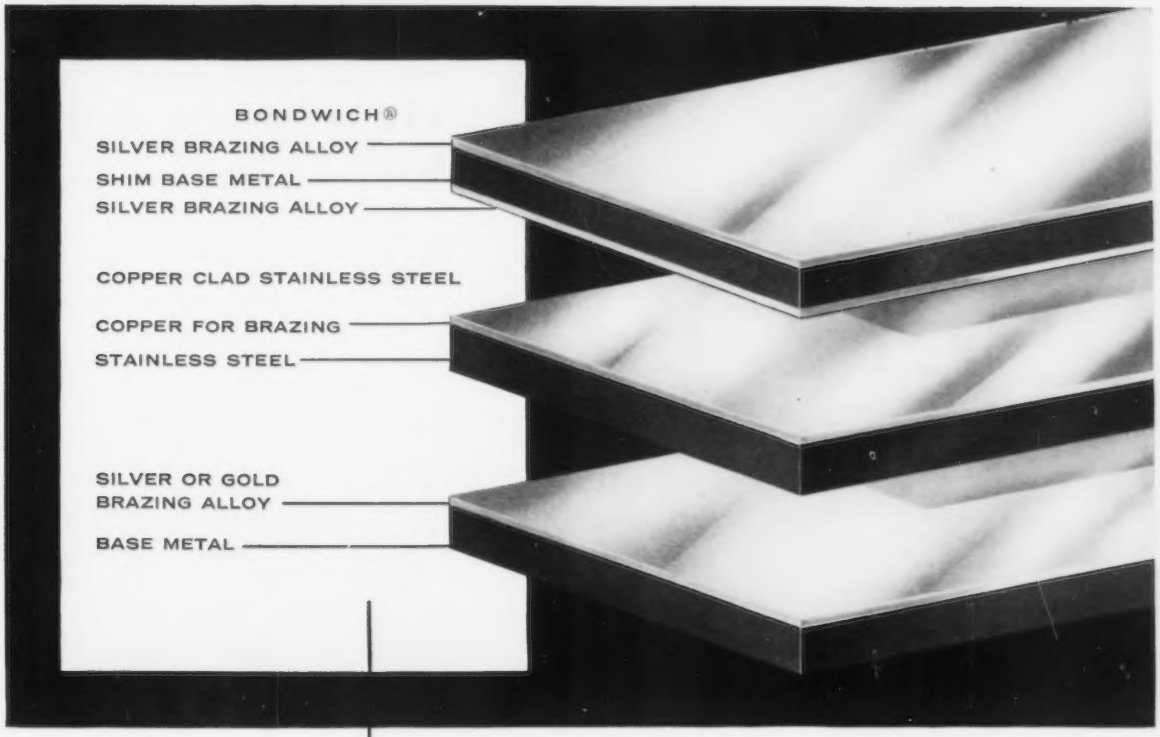
METALS & CONTROLS CORPORATION

Spencer Thermostat Division

3803 Forest Street, Attleboro, Mass.

KLIXON

TWO METALS ARE OFTEN BETTER THAN ONE ...and GENERAL PLATE CLAD METALS for brazing are a case in point–



General Plate can supply you with many clad metals made specially for brazing . . . copper clad stainless steel, silver brazing alloys, clad stainless and non-ferrous metals. Also, soft solders clad on nickel and copper. All are made by permanently bonding a solid layer of brazing metal on one or both sides of the parent metal — which can be either base, precious or clad metal.

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You can profit by using General Plate clad metals.

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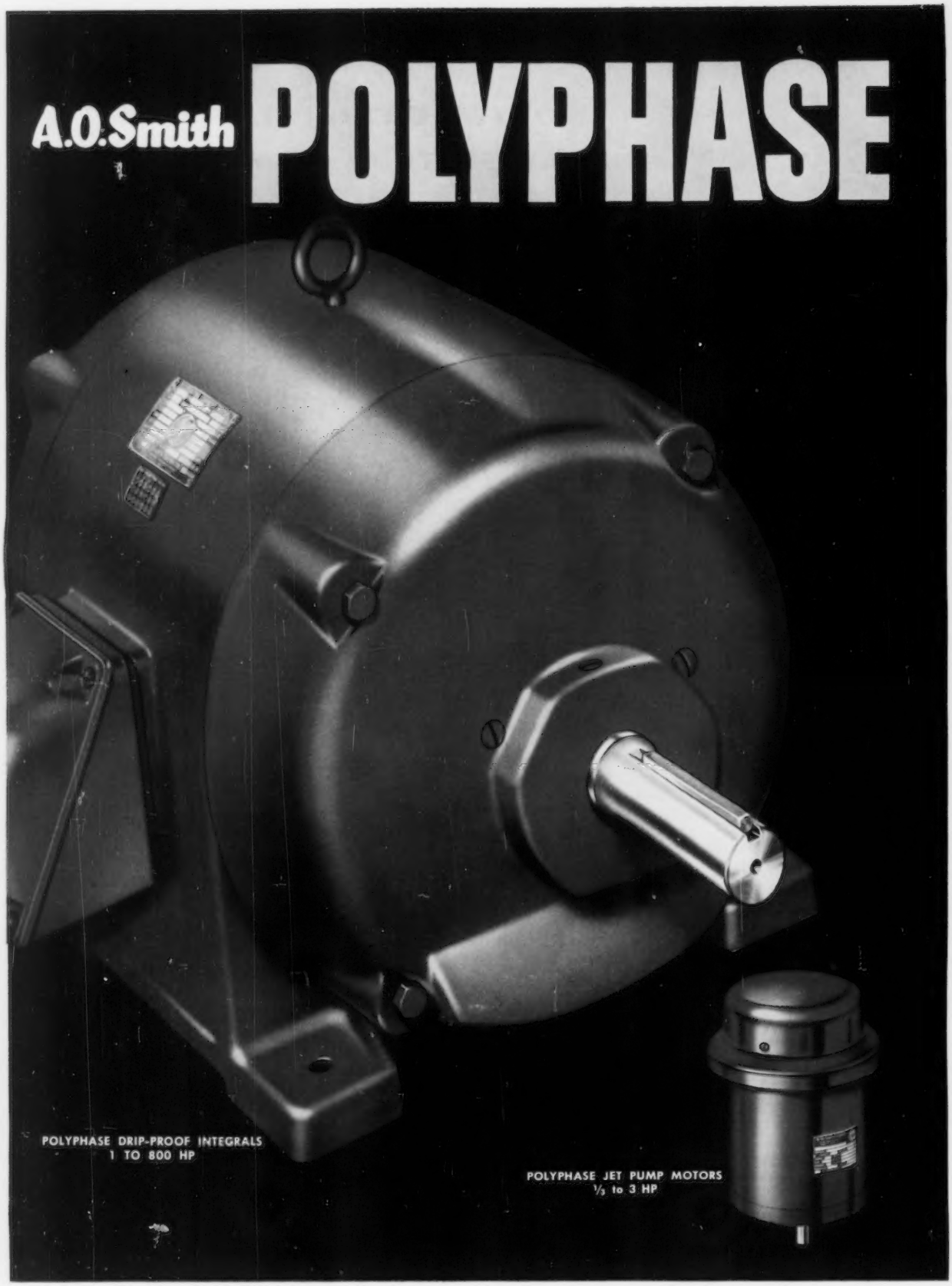
A.O.Smith
POLYPHASE
POLYPHASE DRIP-PROOF INTEGRALS
1 TO 800 HP
POLYPHASE JET PUMP MOTORS
½ to 3 HP

MOTORS

1/3 to 800 hp

YOURS from the case of the A. O. Smith motor man

POLYPHASE FRACTIONALS 1/3 to 1 HP
rigid or resilient bases

VERTICAL HOLLOW SHAFT POLYPHASE
INTEGRALS 1 to 700 HP

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INTEGRALS 1 to 500 HP

CLOSE-COUPLED POLYPHASE PUMP
MOTORS 1 to 150 HP

Here's what amounts to "supermarket" variety — eight basic types of polyphase motors, each available in a wide range of sizes and with practically any electrical or mechanical modification needed.

But in addition to wide choice that helps you get the motor best suited for your application, you get scores of quality features that pay off in uninterrupted service, longer operating life, lower maintenance cost. Every motor is designed to offer ample protection against temporary overloads or voltage drops. You get balanced insulation to afford maximum protection against phase-to-phase or phase-to-ground breakdowns during high amp surges.

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For complete details, contact your A. O. Smith motor man or write direct.

GEARMOTORS 1 to 25 HP are also available with electrical or mechanical modifications to meet your specific requirements.

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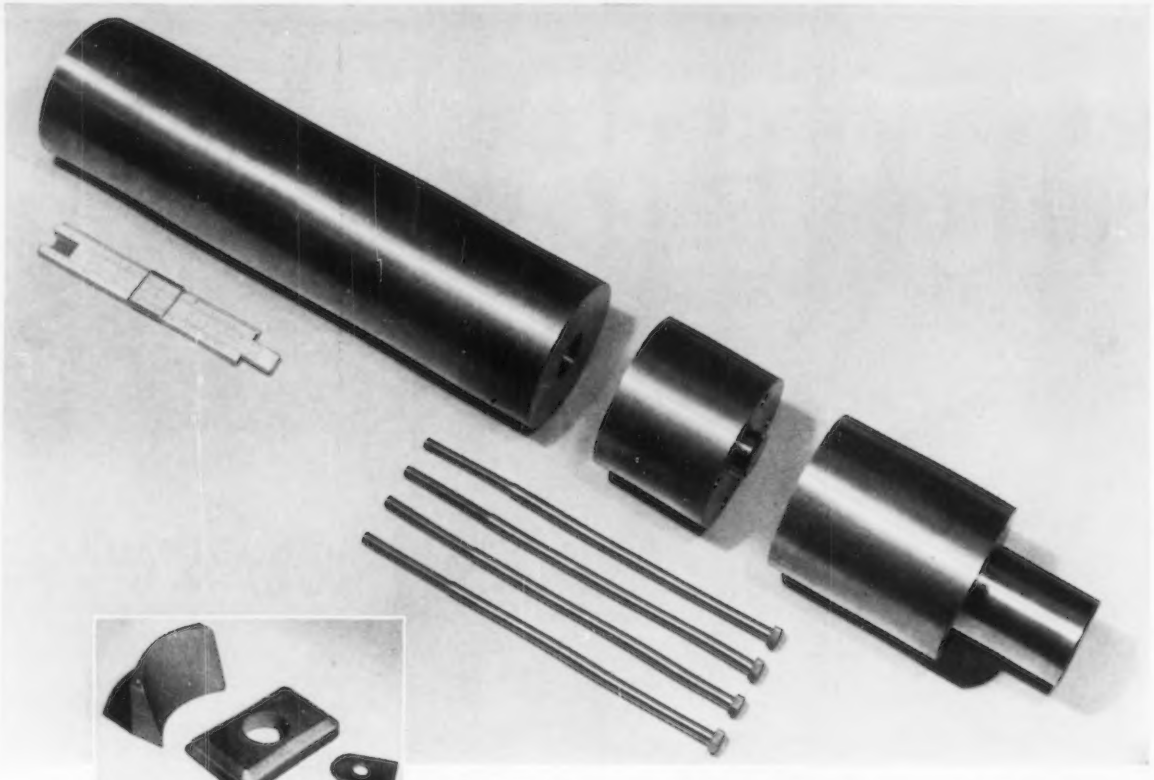

Mallory 1000 Metal provides this 70 pound oil well logging assembly with a high resistance to corrosive elements and with superior shielding ability. In the insert, these tiny pieces were manufactured by Mallory contour pressing—requiring no further machining.

Unique High-Density Alloy Solves Space Problems...at Low Cost

Mallory 1000 Metal is extremely versatile, capable not only of serving both weight and shielding requirements, but serving in big or little shapes with equal ease and efficiency. It can be economically contour-pressed into large or small, simple or complex shapes.

Mallory 1000 is a product of Mallory's advanced metallurgical engineering experience. It is a powder metal that can be compacted to close tolerances and machined to absolute precision—even to a high surface finish. Its density is 16.96 gm/cc . . . twice that of brass or steel . . . and is far stronger than lead.

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Take advantage of Mallory's extensive background and experience in the field of special metals. Complete technical data and application information on Mallory 1000 may be had on request. A skilled engineering staff stands ready to serve as your consultant, no matter how large or small the part or the problem. Write today.

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DEVELOPMENTS TO WATCH...

The latest thing in satellites . . .

. . . says Soviet scientist Yuri Pobedonostev, is a gas-filled plastic bag coated with aluminum foil. It would carry no instruments, but would be designed to reflect sunlight and/or radio impulses from the earth, and would provide information on atmospheric densities, gravitational forces, and other phenomena.

Another type of satellite, now being designed, would carry special equipment to stabilize its position with reference to the earth or the sun. Then, it could be powered by rechargeable batteries that would get their energy from thermoelectric elements exposed to the sun's rays. As a variant of this type, the Russians are considering a model with an axial aluminum tube that would serve as a dipole aerial. The tube could be fitted at one end with a "window" transparent to ultraviolet light, and at the other with one that would transmit gamma radiation. Particle-counters could be installed inside.

Epoxy-resin tubing with rare-earth oxides . . .

. . . is being produced experimentally by Resdel Corp., Rio Grande, N. J. Resdel isn't saying how or where the tubing is used, but rare earths are known to have unusual nuclear, optical, and magnetic properties. Gadolinium, for instance, has the highest neutron-absorption of any material so far tested, and is being evaluated for reactor shielding and control. Other rare earths have unusual optical properties; they're especially sensitive in the ultraviolet and infrared regions. Another possible application for the new tubing, Lindsay Chemical (supplier of the rare earth oxides) suggests: capacitor dielectrics.

Another new job for rare-earth oxides is being pioneered by Allied Resinous Products. It's impregnating polythylene plastic with cerium oxide (up to 90% by weight), for producing a series of materials that look like possible replacements for the pitch and felt laps now used in glass polishing.

Energy-absorbing plastics . . .

. . . that can stand the rough conditions of civilian as well as military life are the subject of a major search by industrial and government laboratories.

Under sponsorship of the Quartermaster General, for instance, National Bureau of Standards is developing new methods for testing the impact behavior of plastics. It's looking toward development of stronger as well as lightweight materials for such ordnance items as disposable parachutes used to deliver military equipment and supplies by air, and also for body armor.

Among the new testing devices being developed by NBS for this study is an impacting machine—actually an adaptation of one originally used to study the stress-strain relationship in yarns. It rotates the specimen at high speed, and subjects it to impact by means of hammer blows on a weight attached to one end. Then, through use of reflecting mirrors, and a high-speed motion picture camera, records position of the impacted and free ends of the specimen.

Paper from fungi . . .

. . . may offer increased flame resistance, could help solve price as well as design problems. At the Institute of Paper Chemistry in Appleton, Wis., paper has actually been produced using fungus filaments instead of wood fibers. Hundred-percent fungus paper is somewhat brittle and difficult to process. But W. M. Van Horn of the Institute says addition of as little as 5% of wood fiber largely overcomes this problem. Furthermore, if the fungus-fiber sheet is calendared under heat and pressure, it becomes smooth, transparent, and flexible, and Van Horn says it takes printing well.

The fungus-fiber process is nowhere near commercialization. However, incorporation of moderate percentages of fungus fiber in wood-fiber mixes might well make it possible to increase paper's flame resistance without changing its processing characteristics—and this could be done quite easily.

DEVELOPMENTS

(continued)

TO WATCH...

Canadians close to thermal barrier breakthrough?

. . . Toronto's *Financial Post* says they are. It reports Aerophysics Institute at U. of Toronto is working on the theory that electric current generated within high-speed aircraft might be used to create an electromagnetic field that could control the flow of gas around the skin, and keep friction-heated air away. It might, also, help to reduce the friction.

Studies are being made with a "plasma wind tunnel" said to have reached speeds 35 to 40 times that of sound, at temperatures of more than 100,000 C. A new magneto-driven tunnel is expected to reach "velocities 400 times the speed of sound, and temperatures of millions of degrees." The Canadians think they're at least two years ahead of the US in this field; but work here is progressing fast (*PE*, Sept. 23, '57 p. 17; Oct. 7, '57, p. 15; Nov. 4, '57, p. 12).

Air-curing, flexible silicone foam . . .

. . . that stands 500 F after it "sets," and can be foamed in a mold or sprayed with a dual gun, is coming soon from Dow-Corning. No date has been set for commercial introduction; but company engineers say the material has passed lab tests, will offer the high-temperature advantages of the firm's now-available rigid form, plus controllable resilience, and perhaps other advantages.

Bottom-loading system for gasoline trucks . . .

. . . is under test by Socony Mobil in the Buffalo area. Company says new self-sealing hose connections "like those used for mid-air refueling of jet planes" make the system practical. Mobil is also conducting large-scale tests of aluminum transports (it has 42 in operation), says they permit an 8% increase in payload and seem well able to stand the rigors of service.

Cold storage improves gasoline . . .

. . . Army Engineers report. Aviation gasoline stored in Arctic ice pits at 15 F, "not only retains its properties, but is even improved after an extended period." The engineers in this case were not conducting gasoline studies, but simply storing fuel as part of their continuing Permafrost research program; but they do believe that part of the improvement may stem from the low moisture content that results from low and constant temperatures; and it looks as though further research would be justified.

Exotic metals go to work . . .

. . . in new electrical and electronic devices, bearings, and structural components as new technology demands long-lasting, high-performance equipment. Indium is now a vital element in transistor construction, is also being used in new storage batteries and conductive coatings for glass. Vanadium, in high-purity form, rates consideration as a structural material for aircraft and nuclear reactors, as well as for a variety of electrical components, including resistors and thermocouples. (For detailed information on these and seven other new and unusual metals, see Mar. 17, '58 issue.) —ARG

Vanadium is easy to machine, has good strength at elevated temperatures, plus useful electrical properties. Here, Electro Met research scientist shows how the metal is supplied (consumable electrode, roundels, arc-melted ingot), and displays experimental electronic components.

French Engineers Take No Back Seat

- **Their patents find steady customers in US**
- **Their metallurgical processes are in wide use**
- **They are making bright progress in jet-age aviation**
- **Computer work ranks close to US**

PARIS—The French may have economic and political troubles that sometimes impede technological progress—but French engineers continue to be the equal of any in the world.

They're developing a mass of techniques that has US, British and German companies steadily buying patent rights. And they show every sign of continuing their advances. Here's a quick roundup of developments in metals, nonmetals, machine tools, electronics and other areas that shows the high level of French engineering:

METALS

The widely used processes for making nickel from low-grade ore, and iron chromium with low carbon content were developed in France. So were Labataille and Sejournet's steel-extrusion methods and Pechiney's aluminum manufacturing process. In 1957, iron and steel production reached 14 million metric tons, 6% greater than 1956. Old blast furnaces are being modernized as new ones are built. These furnaces are rapidly acquiring new faces and compare favorably in loading capacities with the biggest in the world. The Rombas furnace, which produces 600 tons of pig iron per day, is currently one of the best equipped in Europe.

A steel complex, of a type new to France, is about to go up at Dunkirk. Until now, French steel mills were built in the interior next to iron and coal deposits. The new plant, at a major seaport served by canals, should make French steel more highly competitive than ever on the world market.

France, as Western Europe's leading aluminum producer, shows steady advances in aluminum fabricating methods. The rolling and extruding plant at Issiore, built in 1951, is still unequaled in Europe. Its steel-industry-type equipment, including a continuous rolling conveyor, can produce metal plates weighing 2¼ tons.

NONMETALLICS

French technical competence in plastics and rubber is as good as that of any nation. The synthetic fibers Rhovly and Rilsan (a nylon-like polyamide) were developed entirely in France. Demand for French high-grade plastics is strong, particularly for phenoplasts, polystyrenes and aminoplasts. Soaring applications for polyethylene are reflected in three new plants being built on the lower Seine region near petrochemical sources.

Most important resins in France today are: vinyls mainly for pipe sheathing, electrical apparatus, soil surfacing, furniture, packing and raincoats; polystrenes, for insulation, household articles and toys; acrylates and methacrylates, mainly for safety glass and optical items; polyamides, for Rilsan and Nylon; polyethylenes, for electrical construction, household items and packing materials; glycer-phthalic and malics, for varnish, enamel and paints; polyesters for auto parts, ship hulls, roofing and construction sheeting; aminoplastics for casings, electrical apparatus and dishware; and phenoplasts for auto and plane parts, telephone and radio equipment.

Playel, the piano maker, has just developed a new plastic piano. It may change music-industry fabrication concepts.

The Saint-Gobain glass factory at Compiegne, one of the world's largest, has long been the most important glass enterprise in Europe from the engineering-techniques viewpoint. The plant has a continuous, automated glass production line, and an electronic raw material and storing-mixing unit.

In natural and synthetic rubber French engineers have not hesitated in applying unique solutions wherever problems have come up. The Citroen Automobile Co. uses rubber to line almost the entire inside of its DS 19, one of the world's most advanced cars. There are industrial doors in France made entirely of rubber for heavy-vehicle passage.

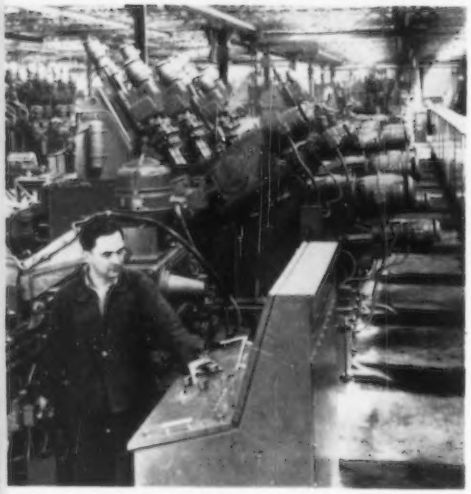
The first butyl plant to be built outside North America is going up near Le Havre. To be completed in 1958 it will have a productive capacity of 20,000 tons of synthetic rubber a year, sufficient to satisfy all of France's needs. Standard Oil of New Jersey granted the rights to this processing method.

MACHINE TOOLS

The French machine-tool builders try to reconcile efficiency, a function of specialization, with versatility, the reason for the so-called universal machine. A typically French solution has been to separate the machine from the spindle and its driving shaft. Thus, drilling units, milling units etc., may be fitted for many jobs.

French designers can now count on twice the precision in workmanship

Atar turbo-reactor
is assembled at S.N.E.C.M.A. factory.



Motor block . . .
fabrication line at Renault automobile's up-to-date Brilliancourt factory near Paris is automatically controlled

than was available 12 years ago. On finishing machines, 0.001 mm. (about 0.00004 in.) is not uncommon. As a result, optical and calibration-instrument design has become outstanding.

French machine tools feature modern power transmission. Newer tools have minimum drive gearing with maximum electrification. French variable-power transmissions easily meet the quality of the best non-French transmissions because of competition from neighboring Switzerland and Germany.

A new slick-slide lathe recently developed by Sculfort-Fockedey-Batier is a good example of unique drive mechanism. The transmission allows 24 forward and reverse speeds in the headstock. Rotation is imparted to the spindle by a multi-disc clutch, which, when released, activates a powerful magnetic brake to stop the spindle almost instantly. The wide range of high speeds and positive transmission of torque at any of these speeds allows use of sintered carbides and ceramic bits.

SOME FRENCH FIRSTS

France is the first country in Europe to manufacture nylon screws. Though this is a development originating in the US their importation was restricted because of the metric system. Another joining method well known in the US, but just recently coming in to wide French usage, is industrial spot welding: point-welding presses are being introduced for the first time.

OTHER DEVELOPMENTS

Electric and gas welding are as common as in the US, and inert-gas welding has been accepted rapidly. In adhesives, France has some of the best plastic glues in Europe.

The variety and efficiency of gasoline engines made in France are well known throughout Europe. In fact, more tiny engines for motorized scooters and bicycles are built in France than in any other country. Engine production for French passenger cars is the fourth highest in the world and third in Europe. In the diesels, French shipyards expect to install the largest Diesel engine in the world rated at 15,000 hp.

The biggest jet-engine maker in France is the state owned S.N.E.C.-M.A. Co., with 10,250 employes. They were the first to build a jet thrust reverser; Aerojet in the US controls the license to manufacture the method. Turbomeca, another jet-engine manufacturer is the company that designed the low-thrust lightweight engines that powered French Helicopters to the world's altitude record. These engines are licensed to Continental Motors in the US. Rene Luduc produced the thermo-propulsor, or ram-jet "022" airplane. The engine in this aircraft is capable of developing the thrust equivalent of 120,000 lb and offers untapped possibilities for pure speed.

NO. 2 COMPUTER MAKER

In electronics and electrical achievements the French rank second only to America. France now wants to compete with US giants in the field of electronic calculators: Bull Co., Paris, has perfected the "Gamma 60," a new computer said to outsell IBM, in France, 7 to 1. The machine can cope with any problem in scientific research, or the broader technical, financial and marketing problems of business enterprises. Bull is also cross-licensed with Remington-Rand and builds other electronic equipment.

The French Company, Compagnie Generale de Telegraphie Sans Fils, has perfected a system of converting radar images to television images. A special memory tube makes it possible to maintain successive radar images and thus, for example, reproduce the path of an approaching aircraft. The electronic image produced is clear even in a lighted room. The system has also been successfully used by the CAA in Indianapolis. CAA considers it superior to other systems suggested to date.

French cybernetics expert, Albert Ducrocq, has just perfected an electronic typewriter of new design called the "Electrostyle." The keys of the typewriter have been replaced with a plastic plaque containing little copper studs that correspond to a word or sound. Ducrocq claims his machine can eliminate the stenotyping stage between dictating and typing the final report. With Electrostyle, typists can keep up with normal dictation.

INTRODUCE NEW CAMERA

In March 1956, at Washington D. C., Americans got their first look at a French created 8-mm camera with an automatically adjusting diaphragm. Basis of the camera is a photoelectric cell that, when influenced by a luminous field, commands a microammeter which in turn controls the opening of a diaphragm. Incidentally, it was a Frenchman who invented Cinemascope.

One of the finest machines in existence for analyzing the chemical content of any material and doing it quickly is the result of the efforts of a Frenchman named Robert Castaing. He developed a machine to measure the velocity of X-rays reflected when an object being tested is bombarded with electrons.

A microwave tube for radar has been sold to Raytheon, and a telecommunications receiver to the Navy.

French-developed electric railroad techniques are about to be used in Japan and India. The French system permits cheaper power usage based on 25,000 volts and 50 cycles, and industrial frequency. The method has lighter gage overhead wire and longer distances between transformer stations, reducing construction costs.

OFFER HYDRAULIC SYSTEM

When the Citroen DS 19 automobile was first presented in 1954 one

of its most unusual features was the hydraulic-gas suspension system. The method represents one of the more advanced applications of hydraulic principles in the world.

In French mining modernization programs hydraulic powered equipment for loading and digging are significant achievements. The technological and increased efficiency through the use of these machines puts France among the first in production of coal within the European Coal and Steel Community. Hydraulically operated mechanisms in France are applied in every feasible manner, ranging from some of the largest presses in Europe to portable jacks for automobiles.

The new French Messier pump will be used to equip the Orpheus jet engine used for the French and foreign interceptor planes coming under the NATO program. This pump has an output of 2860 to 4057 lbs./sq. in. pressure at 4000 rpm under normal operating conditions. It offers a considerable security margin and weighs only 6 lbs. 3 ozs.

What the Autos Want of Plastics . . .

. . . was outlined recently by Charles A. Chayne, GM v-p at the 14th Annual Technical Conference of the SPE in Detroit recently. Applications that could be most helpful to the automotive industry include:

- Adhesives–If metal trim parts could be connected to the car, it would replace the wide variety of fastening clips and accurate hole cutting in body panels.
- External protective coatings–for bright parts to protect them from corrosion should be non-dulling, long-lasting and have a hard surface.
- Plastic fuel lines–to replace the need for rubber seals that now deteriorate because of oil industries use of additives.
- Smear-on Plastics–that would replace extensive body solders, should be just as good, less expensive and lighter in weight. They are yet to be developed.
- Metallic Flake Control–in the production of plastic parts with a metallic appearance.
- New plastics – that combine the strength of thermosets with the ease of processing of thermoplastics. Also, some inexpensive plastics that do not change with age, exposure to sun and other climatic conditions.

Nameplates Speed Info

NEW YORK—Engineers at the Design Engineering Show, Chicago, April 14-15, will be spared the drudgery of filling out inquiry cards for product information. Clapp and Poliak, producer of the exhibit, is distributing plastic nameplates to Show visitors and will equip booths with machines to print plate information on inquiry blanks.

Nameplates can be obtained now from Clapp & Poliak, 341 Madison Ave., New York 17, or at the Show.

Electronics Gives Back Speech

CLEVELAND—Medicine, teamed with engineering, has produced the first electronic larynx, a 6-oz device that reproduces voice tones lost through surgical removal of the larynx.

Patients using the new Cooper-Rand Electronic Speech Aid can produce intelligible tones in the normal 90-to-120-cycle range immediately after a laryngectomy. Dr. Herbert Cooper of the Lancaster Penna. Cleft Palate Clinic, and Rand Development Corp., developed the pocket-sized speech aid. It has only two elements: a battery-powered transistorized oscillator and a tone generator.

The oscillator generates frequencies normally supplied by the vocal chords. The generator takes the electric signal supplied by the oscillator and turns it into sound. Sound is directed into the user's mouth through a small plastic tube. Normal lip and tongue movement turns these frequencies into intelligible speech. Battery life is 30 days or more.

Primary purpose of the instrument is to give the patient immediate speech before he begins his arduous esophageal speech lessons. The device has readily accessible on-off volume, and pitch controls to permit easy operation. Among the few sounds that cannot be made at present is "ing", formed in back of the palate.

Dr. Cooper is working on a dental appliance for use with the Speech Aid that would remedy this limitation. Researchers also envisage an instrument for male patients that would look like an ordinary pipe. The bowl would contain miniaturized sound generator equipment, the stem would serve as speech tube.

Electronically aided speech . . . is now possible for the patient who has just had his larynx removed. Tones transmitted to mouth are tuned into speech by ordinary lip and tongue movements.

Missiles are Better Than Ever

WASHINGTON—The Air Force has a tactical missile to succeed the 600-mi, radar-guided Martin Matador. Martin is prime contractor on the new missile to be guided by an inertial guidance system (made by GM's AC sparkplug div). Immune to jamming and similar to the Navy's Regulus 2 guidance system.

The Air Force has named North American Aviation's top-secret project for development of a B-52-carried air-to-surface missile "Hound Dog." In the works is a more advanced air-to-surface missile, which in effect will be an airborne IRBM to be carried in a chemical or atomic-powered bomber. Thiokol Chemical is developing what the Air Force calls "the largest solid-propellant motor ever built" to power the airborne IRBM. The rocket motor is supposed to have its first static test firing within days. The missile will be operational in five years, according to the timetable.

ALMOST FOOLPROOF

The Air Force claims its new high-powered radar system for detection of ballistic missiles—to cost close to $1 billion—by means of a very complex antenna system, provides precise and sharp beams designed to have a 99%-plus probability of raid detection with a low false-alarm rate. The tracking radar will discriminate between missiles, meteors, and satellites. First contracts, valued at about $329 million are going to RCA as prime contractor; Western Electric, GE, Sylvania, and several other electronic companies are major subs.

The Army's restriction to 200-mile surface-to-surface missiles, has been lifted. The criteria for Army missiles will now be weight and mobility—in other words, if the missile can be carried and launched from a simple motor vehicle, the Army will be allowed to use the missile. The solid-propellant Pershing, now under development at Redstone Ordnance Arsenal, will be the first of this class. It will have a range close to 500 mi and will succeed the 200-mi, liquid-propelled Redstone missile.

NAVY SINGS PRAISES

Although it is not in the outer-space program (aside from the scientific Vanguard project), the Navy claims that an unmanned earth satellite can do more for its mission than for the other two services—as a communications relay, navigational aid, and weather-predicting system.

Comparing Russian and US approaches to engines, a Defense Dept. official said the Russians tend to stress fewer and larger engines to power its missiles and planes. The US, on the other hand, has favored use of more and smaller engines.

An Army expert estimated that Sputnik II was launched by a 3-stage rocket—264,000 lb. of thrust in the first, 80,000 lb. in the second, 40,000 lb. in the third. Top Defense Dept. officials said the US has under development a missile that will produce more thrust than this total—presumably the Titan ICBM.

A two-fold problem has arisen in the Nike-Zeus anti-missile-missile project. What will be used as a target?. Where can test firings be held?

WHO'S DOING WHAT

The Navy is developing a long-range air-to-surface missile, Corvus, for penetration of heavily defended ships and land installations. Temco Aircraft Corp., Dallas, is prime contractor; principal subs are Reaction Motors (propulsion), Texas Instrument Co. (guidance), and W. L. Maxson Corp. (guidance).

Cary Multiplier Co., San Gabriel, Cal., produces the Gyro and controls on the Army's Corporal tactical missile. Grand Central Rocket Co., Redlands, Cal., is developing a solid-propellant rocket for the Army's highly touted Nike-Zeus anti-ICBM missile. Jet Propulsion Laboratory, Pasadena, Cal. and Sperry Gyroscope Co., Salt Lake City, are prime contractors on the Army Sergeant, successor to the 75-mile Corporal. The missile will have a Thiokol Chemical Corp. solid-fuel rocket motor.

Principal subcontractors on the Navy's much-publicized Polaris IRBM (Lockheed is prime contractor on the over-all missile system): MIT, on guidance development; GE, guidance production and fire control; Interstate Electronics Corp., Anaheim, Cal., Instrumentation; and Westinghouse, launcher design.

THE SIDEWINDER STORY

The Navy's sidewinder air-to-air missile developed in a government run installation, has a flock of private producers assembling the end-item or making major components: Philco; GE; Norris-Thermodor, Los Angeles, propulsion—metal parts; Hunter Douglas, Riverside, Cal., propulsion—metal parts; Eastman Kodak, fuse; Minneapolis-Honeywell, fuse; Elgin Watch Co., fuse; Baldwin Piano Co., fuse; Houdaille Industries, Buffalo, N. Y., warheads; Bulova, fuse; Hamilton Watch Co., fuse; Beatrice Field Tank Co., Beatrice, Neb., shipping containers; Allied Federal Industries, Newark, N. J., warhead—metal parts; Electronics Corp. of America, Cambridge, Mass., infrared guidance; IR Industries, Needham, Mass., infrared guidance; Bausch and Lomb, guidance Control; American Machine & Foundry, guidance. A check reveals no other missile involving so many different principal prime and subcontractors.

Fairchild Engine & Airplane Corp. is prime contractor on the Air Force's surface-launched Bull Goose "diversionary" missile. This is an electronic-countermeasure missile without an explosive warhead. It would act as a decoy in a strategic air attack on any enemy. Ramo-Wooldridge Corp. is associate contractor for the electronics. Principal subs are American Machine & Foundry for ground support equipment, and Paul Omohundro Co., Los Angeles, for airframe components.

McDonnell is prime contractor on an Air Force air-launched diversionary missile, Green Quail. Boeing Aircraft Co. has a contract to modify B-52 aircraft to carry the new missile. Ramo-Wooldridge is making the electronics, American Machine & Foundry the support equipment, and GE the powerplant.

Much of this information is revealed for the first time detailing data concerning new missiles. This news bears significance to scientists, engineers and the general public; the latter requiring more and more assurance from government officials regarding the missile-rocket program.

Bits and Pieces

The first advanced home-study course in nuclear engineering technology will be offered this fall by CREI Atomics, Inc., a subsidiary of Capital Radio Engineering Institute, Washington, D. C. . . . A beyond-the-line-of-sight navigational system accurate to within 20 ft. on or above the ground has been developed for land and air use for the army's eventual use by the Pacific Div. of Bendix Aviation Corp.; purpose is to monitor tactical operations of infantry, artillery, armor, missiles and planes.

MAO MOVING UP

. . . Communist China's industrial production for last year was valued at $25.76 billion, which is 7% more than in 1956. Machine building, almost nonexistent in China before World War II, has started production of 2,700 new machine types. . . . British short-range ground-to-air missiles will be deployed during the coming year, and a longer range type is in development. A ballistic rocket of an advanced type and designed for launching from underground is being developed on high priority in close cooperation with the US. Britain also has accepted a US offer to supply IRBM's. . . . Kaiser Aluminum & Chemical Corp. has three new aluminum welding techniques: one, to reduce porosity and dross adds argon and chlorine to the arc's inner core; in a 2nd, nitrogen replaces inert gas in the shielding atmosphere and uses low-flow inert gas in the contact tube, for low alloy aluminum; the 3rd is a low cost code quality MIG process for all weldable aluminum alloys.

LONG RANGE SCIENTIFIC NEED

Dr. E. W. Engstrom, sr. exec. v-p of RCA warned against slighting the long-range need for expansion of the nation's scientific and engineering resources while concentrating on efforts to meet the Russian threat. "It will give us an effective defense, but might leave us tomorrow with far less that is worth defending," he said.

. . . A Dutch four-passenger car for just over $1000 claims to be the first in the world with a completely automatic gear shift at such a low price.

Brainstorming or Logic to Solve Problems?

Los Angeles—"Pot-luck group-think sessions, known as brainstorming" are good fun for kindergarten children or cocktail parties, says Bernard S. Benson of the Benson-Lehner Corp., but they are no way to solve serious problems.

The fad now sweeping engineering labs, the military services, industry, and even the universities may produce a solution to problems, but it is not likely to produce *the* solution, according to Benson. Brainstorming emphasizes a volume of ideas produced at a headlong rush rather than the elegant solution that sprouts from systematic thinking.

Search for the best solution to a problem, says Benson, is an enormous satisfaction to the individual. But beyond that, careful thinking may cut development and construction costs in industry and lead to higher profits. And in national security the optimum solution to problems of nuclear physics or aeronautical engineering may be essential to national survival.

In place of brainstorming or apply the process of "mental popcorn" to problem-solving, Mr. Benson suggests an orderly, logical process. To find a brilliant solution, it is necessary for the investigator first to see the total picture, define his problem and make certain he knows why he wants a solution to it.

Then he can enumerate all approaches that could conceivably provide a solution. This is a function requiring imagination and knowledge. From there he follows a process of logical subdividing and crossbreeding to get the best solution.

As a nation we are inefficient at producing good solutions, says Benson. We are convinced that massive effort and rushing up blind alleys is the only way to solve problems. The incendiary spread of brainstorming he fears, may lead to the super-brainstorming executives of 1967 who will choose a new plant location by blindfolding themselves and playing a spirited game of pin-the-tail-on-the-donkey.

Cosmic Rays Studied

Berkeley — Balloons are being launched by U. of California physicists to study the intensity of cosmic radiation in the upper atmosphere.

The balloons carry a small Geiger counter and radio transmitter. Instruments relay information from an altitude of 60,000 ft. where small variations in the intensity of these rays would be undetectable from the ground.

COMING EVENTS

MARCH

2-6. . . . ASME Gas Turbine Power Div., Conference and Exhibit, Shoreham Hotel, Washington, D. C.

3-5. . . . American Management Association, Annual Electronics Conference and Exhibit, Statler Hotel, NYC.

12-14. . . . Pressed Metal Institute, Spring Technical Meeting, Sheraton-Cadillac Hotel, Detroit, Mich.

17-21. . . . National Association of Corrosion Engineers, 14th Annual Conference and Exhibition, Civic Auditorium, San Francisco, Calif.

16-21. . . . 4th Nuclear Engineering and Science Conference, managed by American Institute of Chemical Engineers with participation by ASME, AIEE, American Institute of Mineral, Metallurgical, and Petroleum Engineers, International Amphitheater, Chicago.

17-20. . . . ASME Aviation Division, Conference at Statler-Hilton Hotel, Dallas, Texas.

19-20. . . . ASME Committee on Management Conference, Somerset Hotel, Boston, Mass.

18-27. . . . International Spring Fair organized by Royal Netherlands Industries Fair, Utrecht, Netherlands.

19-21. . . . American Management Association, Special conference on "How to Manage for Profit in the Small- and Medium-Sized Business," LaSalle Hotel, Chicago.

19-21. . . . International Acetylene Association, annual convention, Bellevue-Stratford Hotel, Philadelphia, Penna.

READER TO EDITOR

Growth of Zinc

To the Editor:

It is considered desirable to comment on "Zinc Makers Planning Major R&D Program." (Jan. 6, p. 35) The writer of the two-column article under the subject quoted a conversation with me quite correctly, but interspersed quotations with other opinions in such fashion that the casual reader would easily interpret the entire statement incorrectly as originating with me. The following is to clarify the impression possibly created:

1. The zinc industry is in the process of embarking on an intensive research and development program.
2. *I* do hold the opinion that the implications of aluminum publicity are frequently subject to a broader interpretation than is correct.
3. *I do not* agree that aluminum die castings are replacing zinc die castings to a significant extent.

The column implies that zinc in the automotive industry is on the decline. The best figures available to the American Zinc Institute indicate the following concerning the use of zinc die castings in the automotive field:

1955—55 lb per average car
1956—61 lb per average car
1957—64¼ lb per average car (tentative)
1958 Models; not available; evidence indicates essentially the same as 1957 models.

There may be room for discussion on the complete accuracy of these or any other similar numbers, but the trend in the present case is clear.

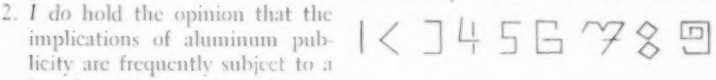
We do not argue with statements on the growth of aluminum in the automotive industry but we do believe that the growth is not to any significant extent from the substitution of aluminum for zinc die castings but rather as a result of its growing use for automotive transmissions, pistons, wheels, etc. A notable exception may be the expanded use of sheet aluminum for grilles which has in some cases replaced zinc die casting or stainless steel. The best evidence at hand indicates that a pickup for zinc die castings in 1958 models has, at least, balanced this loss.

—J. L. Kimberly
Executive Vice President
American Zinc Institute

Lines of Angles

To the Editor:

I have read with great interest the Interesting to Note, "An Angle on Numbers" (Dec. 9, '57, p. 7). I would like to submit one more theory explaining the reason for using the so-called "Arabic Numbers" (the numerical system 1234567890). This theory is based upon number of lines in these symbolic features, as follows:



It is more likely to assume that the primitive shepherd used lines as symbols and not angles which ask for more developed intelligence. (By the way, for describing 4 angles, it is more advantageous to use the simple □

—E. Avivi
Haifa, Israel

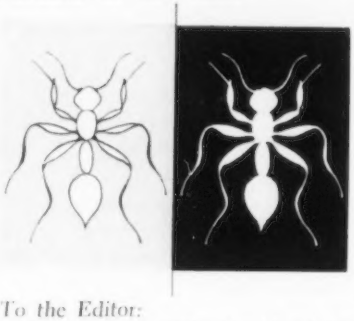
A Letter of Thanks

To the Editor:

Thank you very much for printing my note (Jan. 6, p. 40). I have placed a complete file of Product Engineering dating back to 1932, along with files of several other trade papers, in the library of the Texas Eastern Trans. Corp. Thank you for your help.

—Mrs. Eakin L. Wheless
Shreveport, La.

Parable of the Ants



To the Editor:

Your editorial, "The Parable of the Ants", (Feb. 3, p. 49) was very interesting. Needing very little imagination to substitute nations for Red Ants, White Ants, Beetles, etc., one wonders how the white ants will get out of their dilemma. Will they stop helping the moths, grasshoppers, and crickets, or will they suppress the philosophers and artists?

—F. Harry Neidig
Elma, N. Y.

To the Editor:

Have just finished reading your editorial, "The Parable of the Ants." I enjoyed it very much. However, we have one comment to make. In the "Moral" you said "ants." Are you sure you do not mean "grasshoppers"?

—John P. Mahaffey
Engineering Dept., Joy Mfg. Co.

To the Editor:

Your editorial, "The Parable of the Ants", was excellent.

You've certainly summed up the situation as it stands today. This great country of ours cannot and must not fail in its attempt to unify the world against the "red menace."

Can we blame the people of Europe for their actions in being "very neutral" especially at the risk of being blasted off the face of the earth while we struggle for lost world leadership? I think not. We must prove to them we are able to again assume world leadership, much the wiser.

—Robert C. Palmer
Hartford, Conn.

• These three points of view indicate many current questions to be answered: Can we compete against a "guns" economy, with a "guns and butter" one? Can we, if we lose the loyalty outside our anthill, keep it inside, or will we disintegrate into little political anthills, as France has? Can we overcome our smug superiority and lead the world rather than boss it?—Ed.

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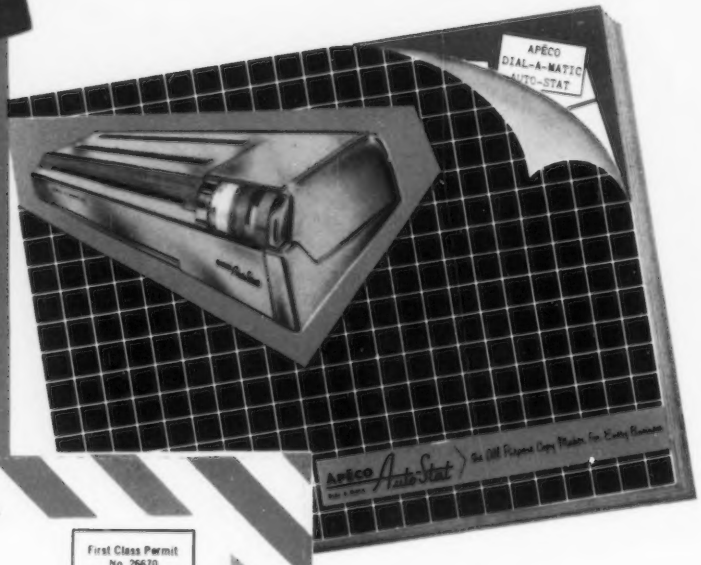

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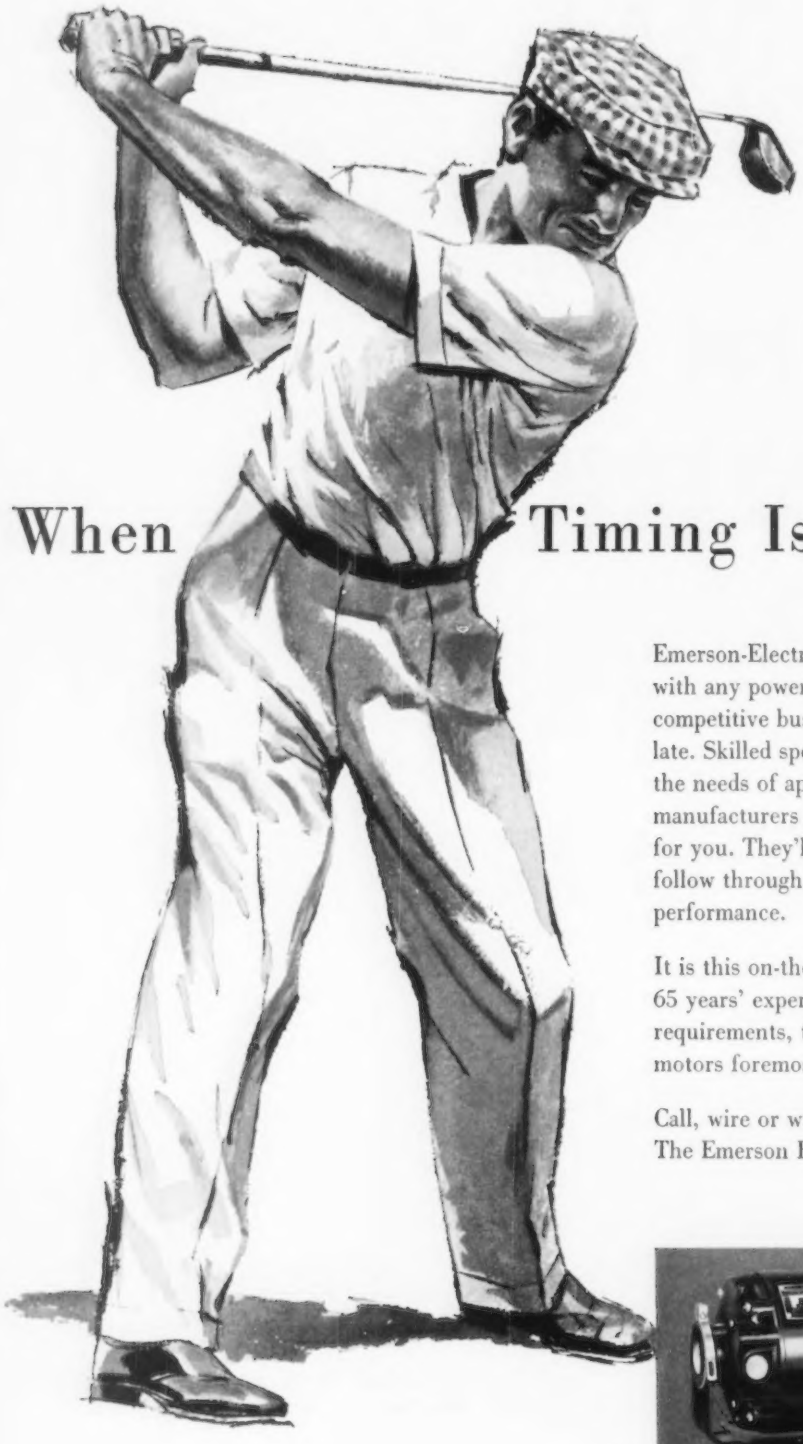

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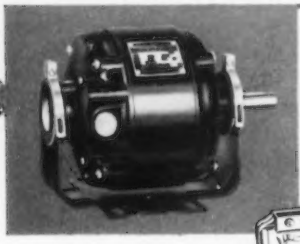

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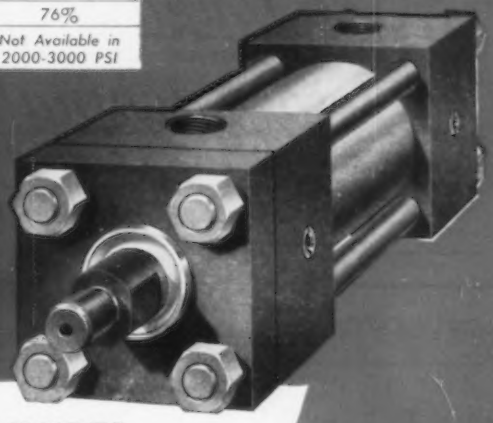

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ARMASTEEL GM 86M	Recommended for less highly stressed parts. Replaces steel parts in 1020-1035 S.A.E. range.	163-207	70,000	48,000	4.0
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ARMASTEEL GM 84M	Recommended for high degree of strength. Replaces heat-treated parts in 1040-1050 S.A.E. range.	241-269	100,000	80,000	2.0
ARMASTEEL GM 88M	High resistance to wear and high yield strength, yet retains machinability. Requires no heat-treating and possesses same strength and wear characteristics as alloy steel forgings.	269-302	105,000	85,000	2.0

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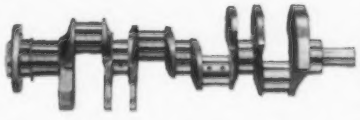
Some of these applications are shown in the table. Look them over carefully; you may find that these characteristics and advantages of ARMASTEEL can help reduce your costs . . . increase your production . . . and improve the performance of your products.

Typical ARMASTEEL castings

Because of the greater physical properties of GM 86M ARMASTEEL, it was possible to redesign this anchor plate as shown and effect a weight reduction from 2.26# per piece to 1.44# per piece.

GM 86M ARMASTEEL provides the ideal casting for this automobile differential case because of its high strength, minimum deflection and good damping qualities which contribute to quietness of operation. Note the as-cast internal cavity and the well-formed webs.



GM 85M ARMASTEEL provides a crankshaft with more desirable machining characteristics than a forged crankshaft of SAE 1045 steel. Improves machining of journals and reduces cheeking stock. Use of GM 85M ARMASTEEL made possible the redesign of the crankshaft with a resulting 3.5# weight reduction and a lower material cost.

By converting to GM 85M ARMASTEEL, drilling and boring operations were eliminated on this crankshaft sprocket. Stock in rough part was reduced from 1.93# in forging to 1.00# in casting. Customer realized reduced piece price with GM 85M ARMASTEEL.

GM 84M ARMASTEEL was specified for this socket plate journal because its microstructure makes it more easily machined than steel with the same physical properties. It has better bearing and wear resistance qualities . . . less distortion during machining . . . and does not require heat treatment. Weight of part in rough is less than comparable steel forging.

Crankshaft for newly designed small gasoline engine. GM 84M ARMASTEEL specified because of outstanding success in similar engines. Less stock removal and better machinability are advantages over forged crankshaft.

This planet gear carrier was formerly forged from SAE 1141 steel, which required a heat treatment after rough machining and broaching operations. By converting to GM 88M ARMASTEEL, heat treatment was eliminated and the weight of the rough part was reduced.

By converting to GM 88M ARMASTEEL for this universal joint yoke, hole thru hub could be cast in . . . eliminating a drilling operation and reducing weight of part approximately 30%. GM 88M ARMASTEEL part has lower piece price than forging formerly used.

85

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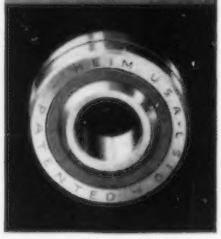
The new General Electric J79 jet engine has the highest thrust-to-weight ratio of any aircraft power plant in production. The engine is rated in the 10,000-pound thrust class.

Variable stators are used for the first time in a flying jet engine, which in a mechanically simplified way, and with far less weight, accomplish the same thing that the dual rotor does in other current engines. The device provides a smooth flow of air inside the engine and eliminates the "stall barrier" problem.



HEIM UNIBAL SPHERICAL BEARINGS and ROD ENDS supply the exact type of linkage, mounting, and degree of misalignment correction required by this engine, and The Heim Company is proud of its contribution to the success of the GE J79.

There are over 200 Unibal Rod Ends assembled with the variable pitch stator blade operating levers.

There are over 50 LS type Unibal Spherical Bearings used as pivot points for the inlet guide vanes.

The bearings which mount the engine to the airframe are three Heim Unibal cartridge units. These bearings carry the entire weight of the engine *and its thrust*.

Other Heim bearings of various types used on this engine bring the total to around 500.

* * * *

The load carrying capacity of Unibal spherical bearings is very high. They are applicable in any linkage where motion must be transmitted at constant or varying angles. They are ideal as supports to any device which is subject to mechanical or thermal deflection.

COMPLETE CATALOG AVAILABLE / SOLD THROUGH THE LEADING BEARING DISTRIBUTORS

THE HEIM COMPANY, FAIRFIELD, CONNECTICUT

INDUSTRY'S MOST ADVANCED DESIGN!

(Patent No. 2,790,882)

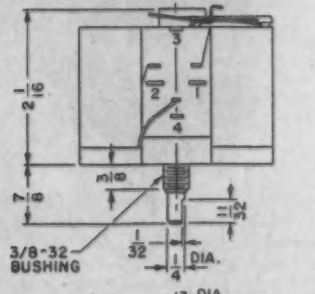
OHMITE® *v.t.* VARIABLE Transformer

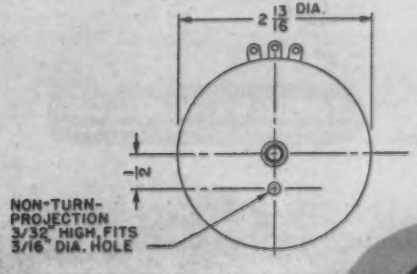
FRONT VIEW
(unmounted)

MORE CAPACITY FOR EQUAL SIZE

MODEL VT1R5—1.5 AMPERES. The rating of 1.5 amperes represents a continuous current rating at any brush setting even at full overvoltage! This "bonus" in current capacity is the result of a unique core design by Ohmite. This new component from Ohmite is made to the same high standards as the famous Ohmite resistors, rheostats, and other components. Other models in larger sizes will be announced soon.

Direct reading dial is calibrated to 120 on one side—132 on the other, for line or overvoltage connections respectively.





In addition to its greater capacity for equal size, the new Ohmite VARIABLE TRANSFORMER, representing industry's most advanced design, features the following quality features:

- *Heavily Plated Rhodium Brush Track* . . . Generous, nonoxidizing plating assures unsurpassed life under demanding conditions.
- *Positive Current Transfer* . . . The contact arm carries no current in this unit! A pigtail shunts the current from the brush, directly to a large copper-graphite slip ring which contacts a large area of the terminal. The spring-like contact arm provides its own completely independent pressure.
- *Rugged INTERNAL Stop* eliminates possibility of damage to contact arm and brush due to application of torque at rotation limits.
- *Ceramic Hub* . . . Mounts and aligns the contact arm, provides 3000 volts ac insulation between parts at line potential and shaft.

AVAILABLE FROM STOCK:
SPECIFICATIONS—MODEL VT1R5
INPUT VOLTAGE—120V, 60 CYCLE.
MAX. OUTPUT AT ANY BRUSH SETTING—1.5 AMPS. OUTPUT VOLTAGE—0-132—0-120.
ANGLE OF ROTATION—320°.
Includes knob, reversible dial plate, washer and nut.
Tandem assemblies available soon.

BACK VIEW

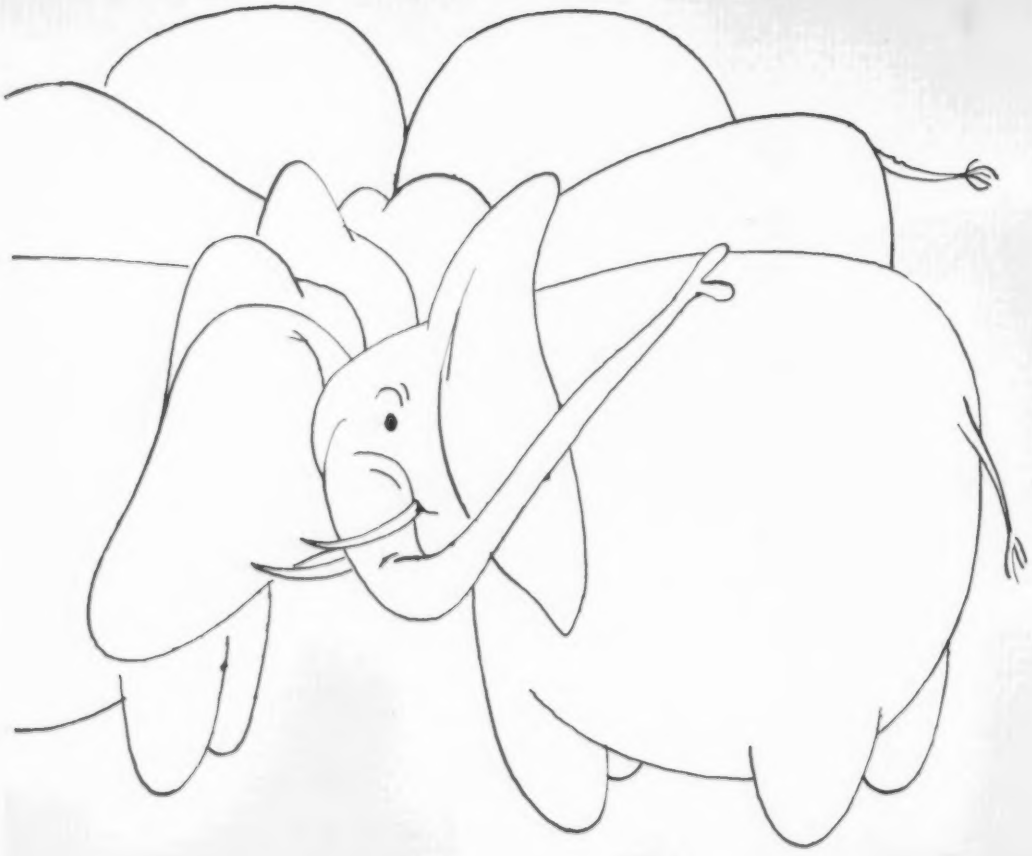
WRITE FOR BULLETIN 151

OHMITE® QUALITY Components

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES • TANTALUM CAPACITORS • VARIABLE TRANSFORMERS

OHMITE MANUFACTURING COMPANY
3611 Howard Street, Skokie, Illinois

something big on the move

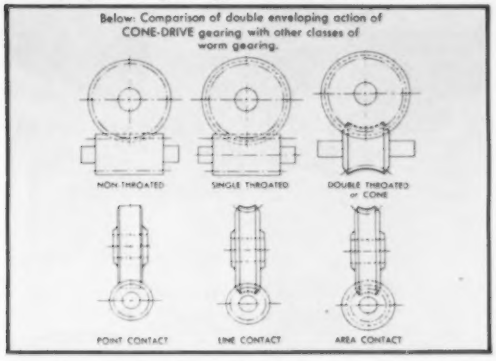


ANOTHER ENGINEERING FIRST FROM T·J TOMKINS-JOHNSON

Don't Miss It at the ASTE Show, May 1-8, Booth 1423

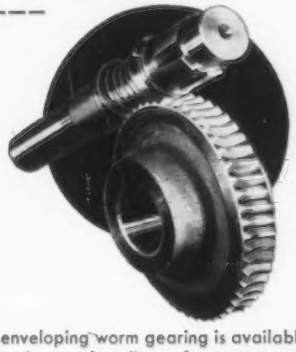
How to get the most out of Worm Gearing

If a right-angle drive is needed in your product and you require maximum capacity for your dollar, then the Cone-Drive double-enveloping type will give it to you. The sketch below shows the apparent advantages of Cone-Drive gearing as compared to other worm gear types. Double-enveloping worm gearing, the most modern and efficient

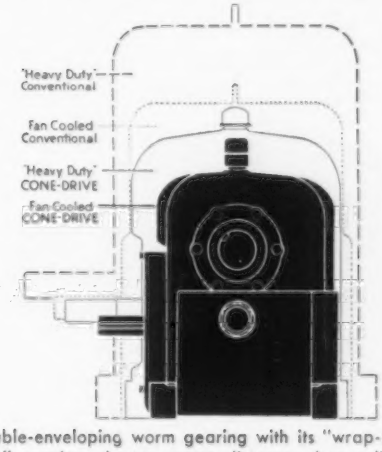

Below: Comparison of double enveloping action of CONE-DRIVE gearing with other classes of worm gearing.
NON THROATED
SINGLE THROATED
DOUBLE THROATED or CONE
POINT CONTACT
LINE CONTACT
AREA CONTACT

form, has straight-sided teeth in both worm and gear. Both elements of Cone-Drive are throated and envelop each other, providing a multiple tooth area contact. This means greater load-carrying capacity than is possible with any other type of worm gearing.

Speed reducers and gearmotors with Cone-Drive double-enveloping worm gearing are unusually compact and powerful drives that handle shock loads with ease. Yet, they provide power transmission smoother than that of hydraulic systems. Another advantage, unique to double-enveloping worm gearing, is their ability to regenerate themselves when wear occurs. Both worm and gear tend to reproduce the correct form in the other when wear occurs.



Double-enveloping worm gearing is available from Cone-Drive Gears in complete lines of gearsets, speed reducers and gearmotors. Gearsets are stocked in center distances from 2" thru 24", capable of handling loads from fractional to over 1600 horsepower. A complete line of mountings for gearsets is also stocked.



Double-enveloping worm gearing with its "wrap-around design" requires shorter center distances than cylindrical worm gearing to handle the same loads. As a result, Cone-Drive speed reducers have smaller housings with corresponding savings in weight and space. Bulky gear trains can often be replaced with a single Cone-Drive speed reducer or gearset.

DOUBLE-ENVELOPING WORM GEARSETS
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS
DOUBLE REDUCTION WORM GEAR SPEED REDUCERS
DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

CONE-DRIVE GEARS
DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols Road • Detroit 12, Michigan
Telephone: TWinbrook 1-3111

Please send me information on following:

☐ Gearsets ☐ Gearmotors ☐ Speed Reducers

Name_____

Title_____

Company_____

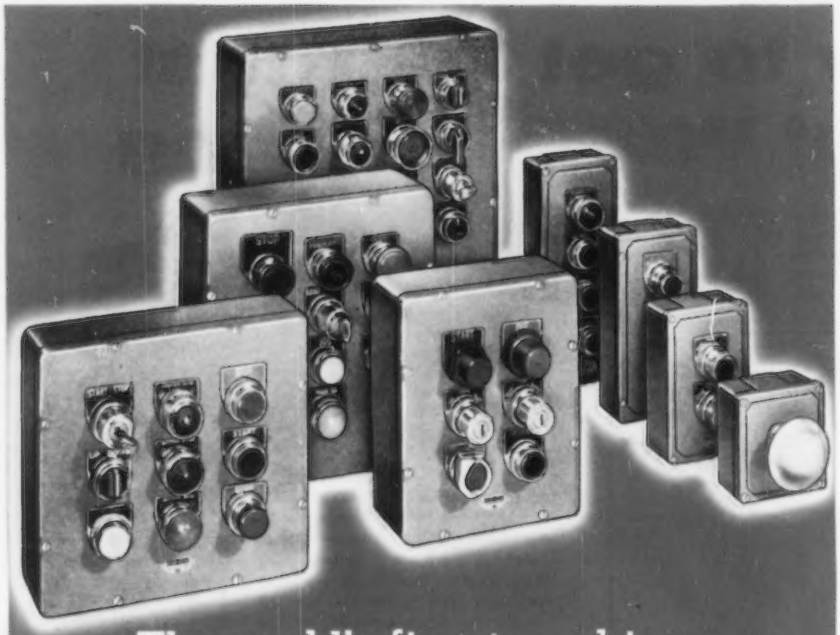
Street_____

City_____ State_____

TEAR OUT AND MAIL IN FOR COMPLETE DATA

TEAR OUT AND MAIL IN FOR COMPLETE DATA

TEAR OUT AND MAIL IN FOR COMPLETE DATA



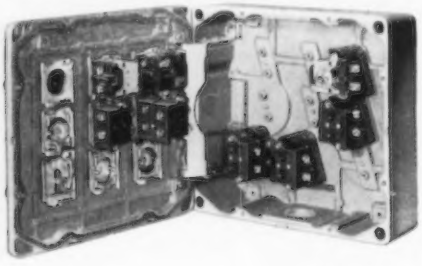
The world's finest machines are controlled from Cutler-Hammer oil-tight pushbutton Control Stations

The Cutler-Hammer line of heavy duty oil-tight pushbuttons and precision die-cast control stations surpass anything ever before available to serve the needs of machine design engineers. Cutler-Hammer Oil-Tight Control Stations are precision die-castings to permit both base and one-hole mounting of the control units. The one to four element control stations are available in either the normal depth or the exclusive shallow depth for use where space limitations are critical.

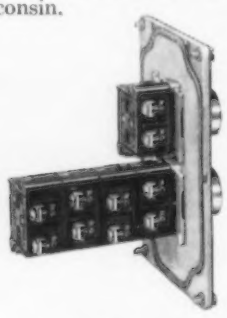
Cutler-Hammer Pushbutton contact blocks are easily tandem mounted without special adapters, and use less behind-the-panel space than any other. Circuits can be arranged in any combination of NO and NC contacts.

Indicating lights come in a wide selection of colors with either plastic or glass lenses. Among the many special operators are: Roto-Push®, the combination pushbutton-selector switch; PresTest®, the self-testing indicating light; knob, key, lever, and coin type selector switches; flush, long, mushroom head, guarded, and palm type pushbutton operators.

Write today on your company letterhead for the illustrated booklet EL-178, Master Design. CUTLER-HAMMER Inc., 1332 St. Paul Avenue, Milwaukee 1, Wisconsin.

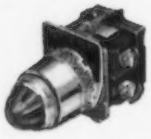


The hinged cover on the larger Oil-Tight Control Stations facilitates assembly and alterations. Precision die-castings permit both base and one-hole mounting of the control units. Raised edge on the box mates with the neoprene-cork cover gasket for a perfect seal.



Complete line of cover plates for cavity mounting. Compact contact blocks take 40% less space behind the panel than the next smaller element . . . additional blocks easily tandem mounted . . . from 2 to 8 separate circuits in any combination of NO or NC contacts.

Special Purpose Operators and Accessories



PresTest—the self-testing indicating light

Guarded mushroom head operator

Neoprene protective boot for flush or long button operators

Indicating lights, six colors available with plastic or glass lenses

Roto-Push—the one button control station . . . with or without lever ring in a deep precision die-cast enclosure

Selector switches—knob, lever, key, coin

CUTLER-HAMMER
MOTOR CONTROL
C-H

How Armco 17-4 PH Stainless gives shafts longer life at low cost

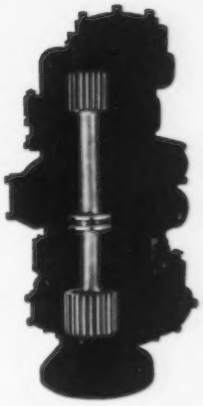
Armco 17-4 PH Stainless Steel is specified for shafts like these because it provides an unusual combination of high strength and hardness, good corrosion resistance and excellent fabricating characteristics. Where operating conditions are severe, designers have found this special Armco Stainless Steel assures economical and long, unfailing service.

High Strength Plus Corrosion Resistance

Mechanical properties of 17-4 PH show why it can be used to make shafting and other critical parts stronger, more resistant to galling and wear.

Typical Properties Armco 17-4 PH Bar (Hardened at 900 F for 1 hour)

Ultimate tensile strength, psi	180-210,000
0.2% Yield strength, psi	165-200,000
Elongation in 2", %	8-17
Hardness, Rockwell	C40-45
Endurance limit, psi (100 million cycles)	80,000



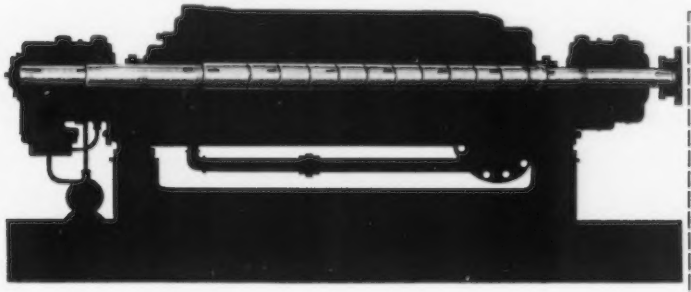
Excellent properties up to 900 F also extend the advantages of 17-4 PH to elevated-temperature applications.

In addition to high strength, this special stainless offers good corrosion resistance. It is much better than that of the hardenable chromium grades and as good as Type 302 under many conditions.

Simple, Low Cost Fabrication

Armco 17-4 PH is readily machined, forged or welded. Hardening requires only 1 hour at 900 F. This low temperature heat treatment, by eliminating scale and minimizing distortion, permits most parts to be finish-machined before hardening.

For parts of *your* products that require ultra-high strength plus corrosion resistance, consider the many design and production advantages of Armco 17-4 PH Stainless Steel. It is available in bar, wire and billets. Just fill out and mail the coupon for complete information.



ARMCO STEEL CORPORATION
1528 Curtis Street, Middletown, Ohio

Send me information on Armco 17-4 PH Stainless Steel

NAME_____

COMPANY_____

STREET_____

CITY_____ ZONE___ STATE_____

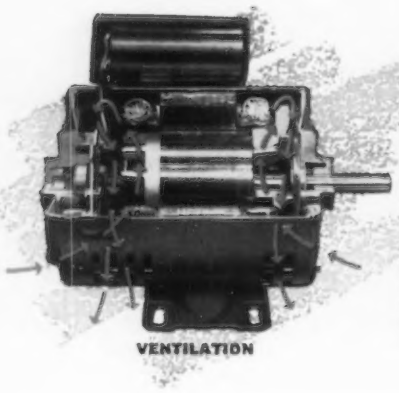
ARMCO STEEL

ARMCO STEEL CORPORATION, 1528 CURTIS STREET, MIDDLETOWN, OHIO

SHEFFIELD DIVISION • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION

available in . . .
SPLIT PHASE,
PERMANENT SPLIT CAPACITOR,
CAPACITOR START-INDUCTION RUN,
POLYPHASE

NEW!



VENTILATION

CLEAN, MODERN DESIGN—Lightweight, die-cast aluminum head ends accurately fit precision machined steel body, assuring rigidity and good alignment. External finish is smooth, flow-free . . . blends well with any color.

IMPROVED, DOUBLE-END VENTILATION—Ventilating fans are integral with die-cast aluminum squirrel cage rotor, providing effective cooling of the windings from both ends for long life. Properly located openings give maximum cooling with minimum internal parts exposure.

MYLAR* POSITIVE INSULATION—Mylar* polyester film laminated to rag paper insulates slot cells and other strategic areas. Excellent dielectric qualities and resistance to tearing and aging, affording virtually permanent protection against dust, moisture and heat damage.

CHOICE OF MOUNTINGS, BEARINGS—Rigid, welded base or vibrationless, ultra-quiet resilient mounting with motor hubs floating on rubber cushioning rings permanently bonded to inner and outer metal bands. Either sleeve type or fully sealed ball bearings available. If desired, special construction permits re-lubrication of ball bearings. Bearings seat in precision bored steel rings cast into the aluminum heads.

**DuPont registered trademark*

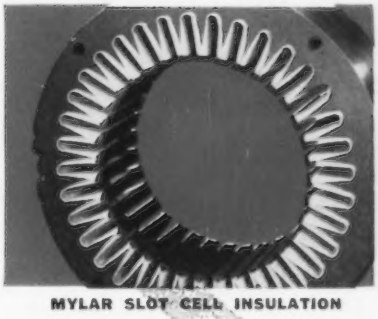
Robbins & Myers build motors from 1/200 to 200 horsepower

R&M

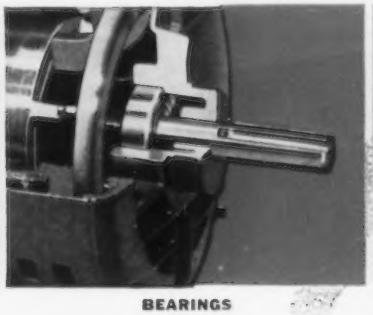
R & M's BROAD LINE OF SMALLER, LIGHTER, FRACTIONAL HP MOTORS

Robbins & Myers Re-Rated Frames 56 and 48

Here's a dynamic new motor—smaller, lighter, more versatile than older frame motors—yet with undiminished performance and reserve power. Completely new R&M "Model R" fractional horsepower motors will perform dependably and enhance the appearance and acceptability of your products. They range from 1 to ⅛ HP in types for all your applications: polyphase, permanent split capacitor, capacitor start single phase and (in the smaller ranges) split phase types. Designed in new NEMA frames 56 and 48, they are *lighter* due to new applications of aluminum, steel and copper . . . *smaller* thanks largely to a unique new ventilating system . . . *more versatile* because of weight, size and many other design features involving frames, mountings, insulation etc. Look over the big advantages these motors offer you! Then write today for R&M Bulletin No. 450–PE.



MYLAR SLOT CELL INSULATION



BEARINGS

TOTALLY ENCLOSED—FAN COOLED

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

LIVE BETTER ELECTRICALLY

MOTORS

FANS

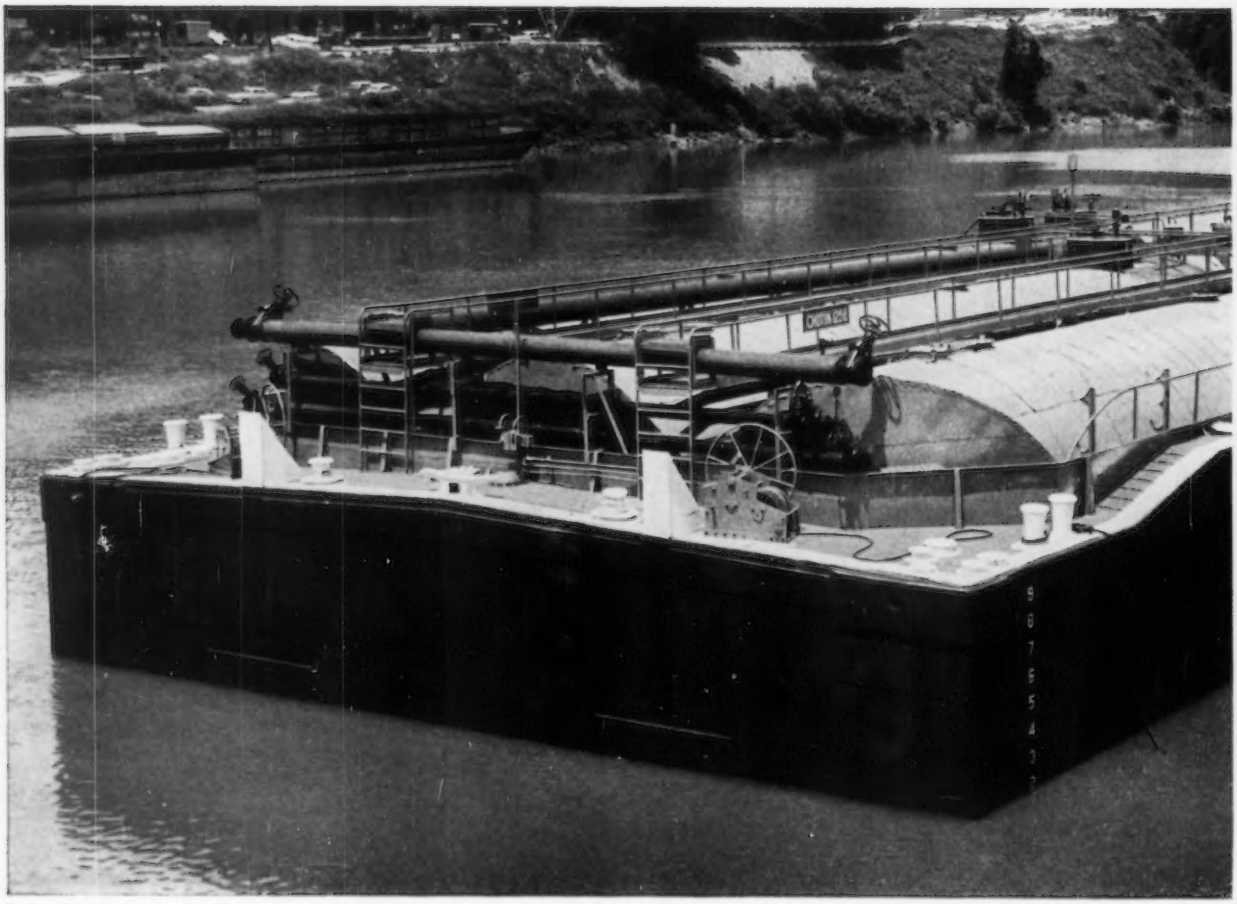
HOISTS

® MOYNO PUMPS

PROPELLAIR FANS

For whatever you make . . .

N-A-X® HIGH-TENSILE STEEL MEANS LIGHTER WEIGHT WITH LONGER LIFE



Light weight and shallow draft make the ideal commercial river barge. Thanks to the inherent qualities of N-A-X HIGH-TENSILE steel, this river barge designed and built by Nashville Bridge Company, Nashville, Tennessee, offers a weight reduction in excess of 10% over mild carbon steel—plus longer life and increased payload capacity with shallower draft.

Operators like the way weight-saving N-A-X HIGH-TENSILE improves barge towing efficiency—less draft when loaded; less dead weight to pull when empty. That means savings on operating costs all the time. And, again thanks to N-A-X HIGH-TENSILE, barge operators get more resistance to corrosion. For this manufacturing job, like so many others, N-A-X HIGH-TENSILE steel provides desirable lightness with greater durability and strength.

Check These Important Advantages for Your Job: The N-A-X HIGH-STRENGTH steels—both N-A-X HIGH-TENSILE and N-A-X FINEGRAIN—compared with carbon steel, are 50% stronger • have high fatigue life with great toughness • are cold formed readily into difficult stampings • are stable against aging • have greater resistance to abrasion • are readily welded by any process • offer greater paint adhesion • polish to a high luster at minimum cost.

Although N-A-X FINEGRAIN'S resistance to normal atmospheric corrosion is twice that of carbon steel, N-A-X HIGH-TENSILE is recommended where resistance to extreme atmospheric corrosion is important.

For whatever you make, from steel shop boxes to steel river barges, with N-A-X HIGH-STRENGTH steels you can design longer life, and/or less weight and economy into your products. Let us show you how.

This barge, built by Nashville Bridge Company, hauls hot asphalt between Baton Rouge and other points along the Mississippi-Ohio River system. Both the barge hull and the cargo tanks are made of N-A-X HIGH-TENSILE. Weight reduction: in excess of 10% compared with mild carbon steel.

N-A-X® HIGH-STRENGTH STEELS

N-A-X Alloy Sales Division, Dept. C-2

GREAT LAKES STEEL CORPORATION

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NATIONAL STEEL CORPORATION

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Great Lakes Steel Corp., Detroit 29, Michigan

☐ Please send me 12-page illustrated technical catalog on N-A-X HIGH-STRENGTH steels.

☐ Please have your representative contact me.

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FOR DOWN-TO-EARTH COMFORT FIVE MILES UP...

TWA SPECIFIES URETHANE FOAM CUSHIONING

Passenger comfort is a highly competitive product in the airline industry, which is one of the reasons why such strict and careful testing precedes the selection of seating design and cushioning materials by major airlines. It is also why the Siesta Sleeper seats of TWA's sleek, new *Jetstream** liners are all full-cushioned with soft, luxurious, easily-cleanable and fire-resistant urethane foam.

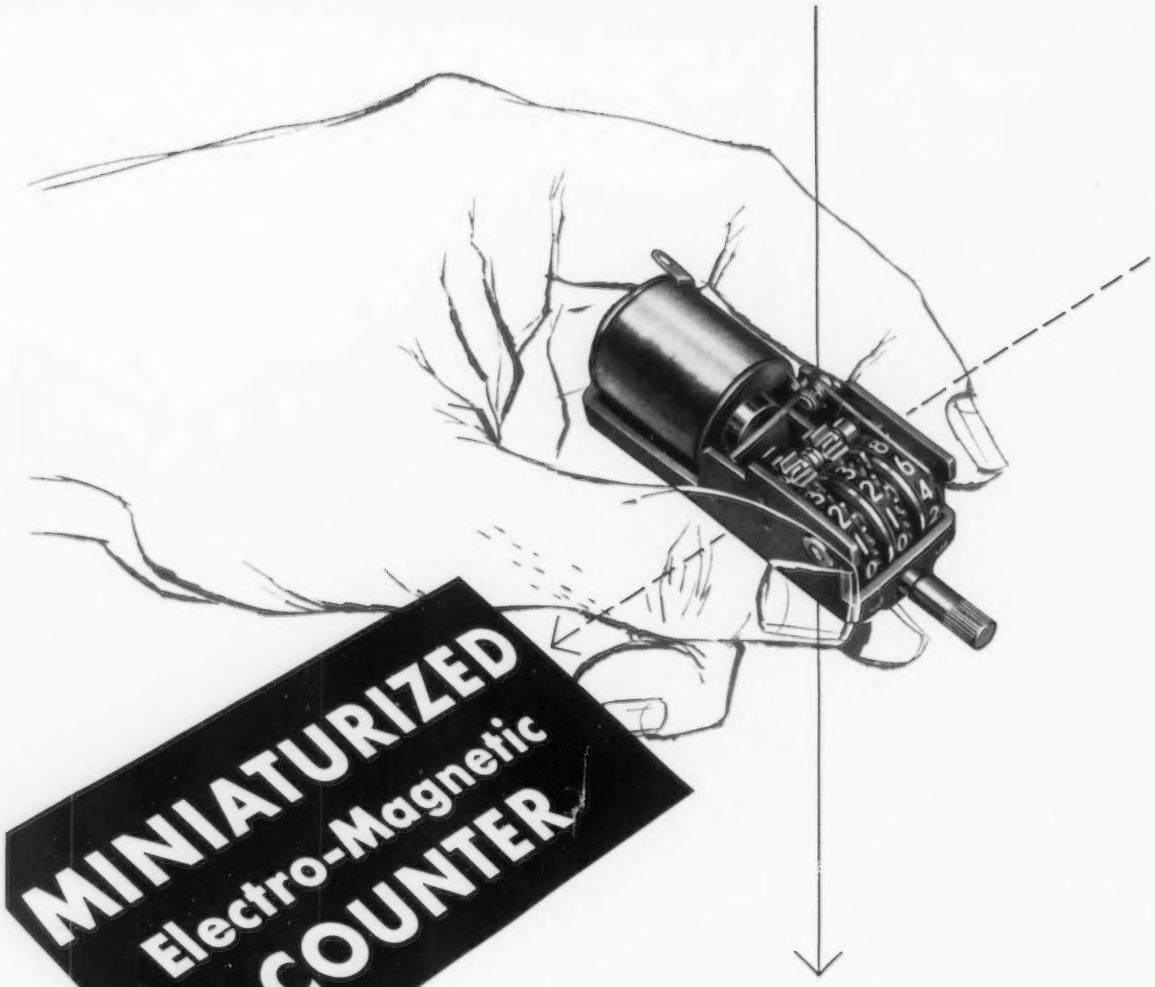
Many of the world's leading upholstered furniture and seating designers endorse urethane foam as the ultimate in luxury cushioning—the best way to combine lounge-chair comfort with design and fabricating economies.

If comfort is one of the "products" you sell or buy, get acquainted with urethane foam and discover what you've been missing! For further information and sources of supply for urethane foams, write **Mobay Chemical Company, Dept. P-6, Pittsburgh 34, Pa.**

***JETSTREAM** is a service mark owned by TWA exclusively*

Mobay supplies quality chemicals used in the manufacture of urethane foams for industry. Urethane foam for this product supplied by American Latex Products Corporation.

MOBAY
First in Urethane Chemistry



MINIATURIZED Electro-Magnetic COUNTER

Newest News from VEEDER-ROOT

Series 1527 Veeder-Root Miniaturized Electro-Magnetic Counters were originally developed for use in aerial cameras. These and similar counters are used to "post" the number of film-exposures, gallons or rounds of ammunition remaining after each use.

The new miniaturized counters present a frontal area less than 1" x 1" . . . save an important amount of space over the older, larger counters. Yet they are designed to operate at speeds as high as 900 counts per minute. And this modern design includes a new push-in bi-directional reset knob, with speed-up gearing. Specifications meet most military requirements. Write for full details.

Added Evidence that Everyone Can Count on

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INCORPORATED
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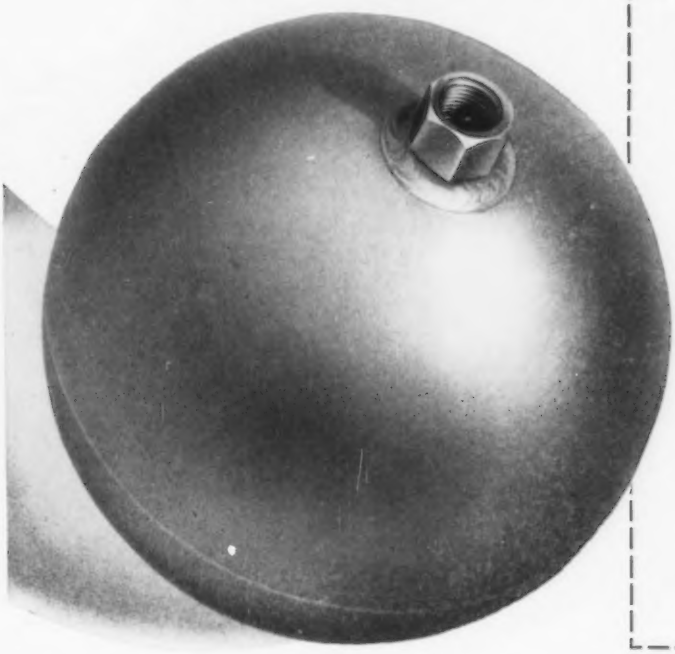
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

need floats?



Name the way you want them!

MATERIAL_____
SHAPE_____
SIZE_____
PRESSURE_____
QUANTITY_____
MORE INFO_____

*Your Name*_____
*Title*_____
*Company*_____
*Address*_____

See below for details
Fill in blanks, tear out, and mail to:
W. H. NICHOLSON and COMPANY
Wilkes-Barre, Pa.

Nicholson can deliver precision welded floats —made to your specifications—to fit your production schedule. Use the above form to tell us how you want them.

Here are the standard specs:

- **MATERIAL**—steel floats with chromium, cadmium or copper plating—with sandblast or pickled finish . . . stainless steel and Monel floats—rough-buffed, polished or with welds ground smooth and highly finished.
- **SHAPE**—spherical, elliptical, cylindrical.
- **SIZE**—from 2 inches to 14 inches diameter.
- **PRESSURE**—from vacuum to 4800 lbs.
- **QUANTITY**—as many as you need.

These high tensile strength floats have exceptional resistance to pressure and corrosion. Float halves are die-formed, with inward rolled edges—not spun, laminated or electrodeposited.

Today, thousands of Nicholson floats are in service—most as buoyancy mediums . . . many as fluid chambers and pressure vessels. Write for details about the full Nicholson line.

W. H. NICHOLSON AND COMPANY, 12 OREGON ST., WILKES-BARRE, PA., *Sales and Engineering offices in 98 principal cities.*

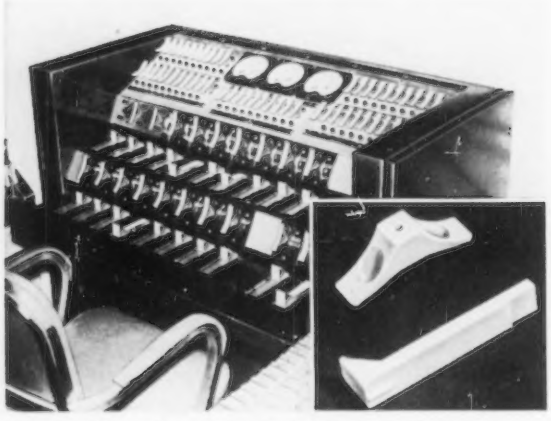
NICHOLSON
of Wilkes-Barre

CYANAMID

PLASTICS IN ELECTRICAL DESIGN

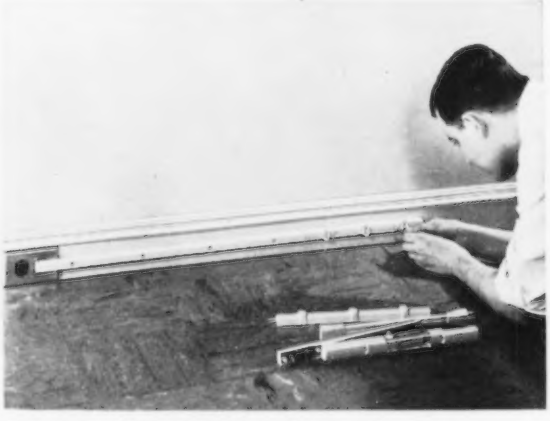
An Ounce of Protection

KLIXON precision aircraft circuit breakers have to be light; yet even the smallest, weighing about 1¼ ounces, can safely interrupt a 120-volt ac, 400-cycle circuit delivering over 4000 amperes. To provide the high arc resistance and great physical strength required, Spencer Thermostat Div., Metals and Controls Corp., uses glass-filled CYMEL® melamine plastic housings. These non-corrosive housings are excellent insulators and stand up to impact, humidity, dust, temperature extremes and fire.



Plastic Keys Conduct Orchestra of Light

The Lumitron Lighting Control System permits one operator to play infinite variations in stage-lighting effects using handles and slide bars molded of BEETLE® urea plastic. BEETLE, an excellent dielectric, requires no insulation. Molded-in colors are permanent, permit quick circuit identification for console operator. Developed by Metropolitan Electric Manufacturing Company, the Lumitron has an excellent record of dependable performance.



New Low-Cost Electrical Outlet System

Made of ivory-colored BEETLE urea molding compound, new interlocking foot-long units provide low-cost, easily installed electrical outlet extensions. BEETLE combines good mechanical and dielectric properties for safe, dependable service, meeting ASTM Specifications D705-49, Grade I. Made by Cable Electric Products, Inc., this new Snapit Inter-Link System is fully approved by Underwriters Laboratories, Inc.

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PERSPECTIVES

in design and development . . .

National Science Foundation: It's Suddenly Popular

With the nation's scientific programs coming up for inspection by Congress, one result seems sure—the National Science Foundation will take on a greater stature.

Congress already has several proposals before it that call for widening the Foundation's activities; others are likely to come. The administration has asked for a record-breaking NSF budget for fiscal 1959—$140 million—more than three times last year's budget.

Although Congress set up the National Science Foundation back in 1950 to shape the nation's basic research policies and programs, the agency did not receive much attention or support from the legislators until after Sputnik. The Russian satellites, however, brought a change. And, in the current all-out push to pump vigor into basic research, the Foundation may emerge as a top-ranking organization.

Only Eight Years Old

The National Science Foundation was established by Congress in 1950 to "develop and encourage the pursuit of a national policy for the promotion of basic research and education." Specifically, it was ordered to support basic scientific research in mathematics, physics, engineering, biology, and medicine; to award scholarships and fellowships in these fields; to promote the interchange of scientific information among scientists here and abroad; to evaluate other government agencies' scientific research programs; to correlate the Foundation's programs with those of private and public research groups; maintain a register of scientific and technical personnel in the US; and undertake specific research projects relating to national defense.

Who Operates NSF

To carry out the functions of the Foundation, Congress set up a 24-member National Science Board and a director. The board members and the director are appointed by the President, subject to congressional approval, for six-year terms.

Present chairman of the board is Dr. Detlev W. Bronk, President of the National Academy of Sciences. Other members include Warren Weaver, Vice President for the Natural and Medical Sciences, The Rockefeller Foundation; Roger Adams, Research Professor, Department of Chemistry and Chemical Engineering, Univ. of Illinois; Charles Dollard, President (retired) Carnegie Corp.; and Theodore M. Hesburgh, C. S. C., President, Univ. of Notre Dame.

Director is Dr. Alan T. Waterman. Below the director, the Foundation has three divisions and two offices. These are: Div. of Biological and Medical Sciences; Div. of Mathematical, Physical and Engineering Sciences; Div. of Scientific Personnel and Education; the Office of Scientific Information; and the Office of Special Studies.

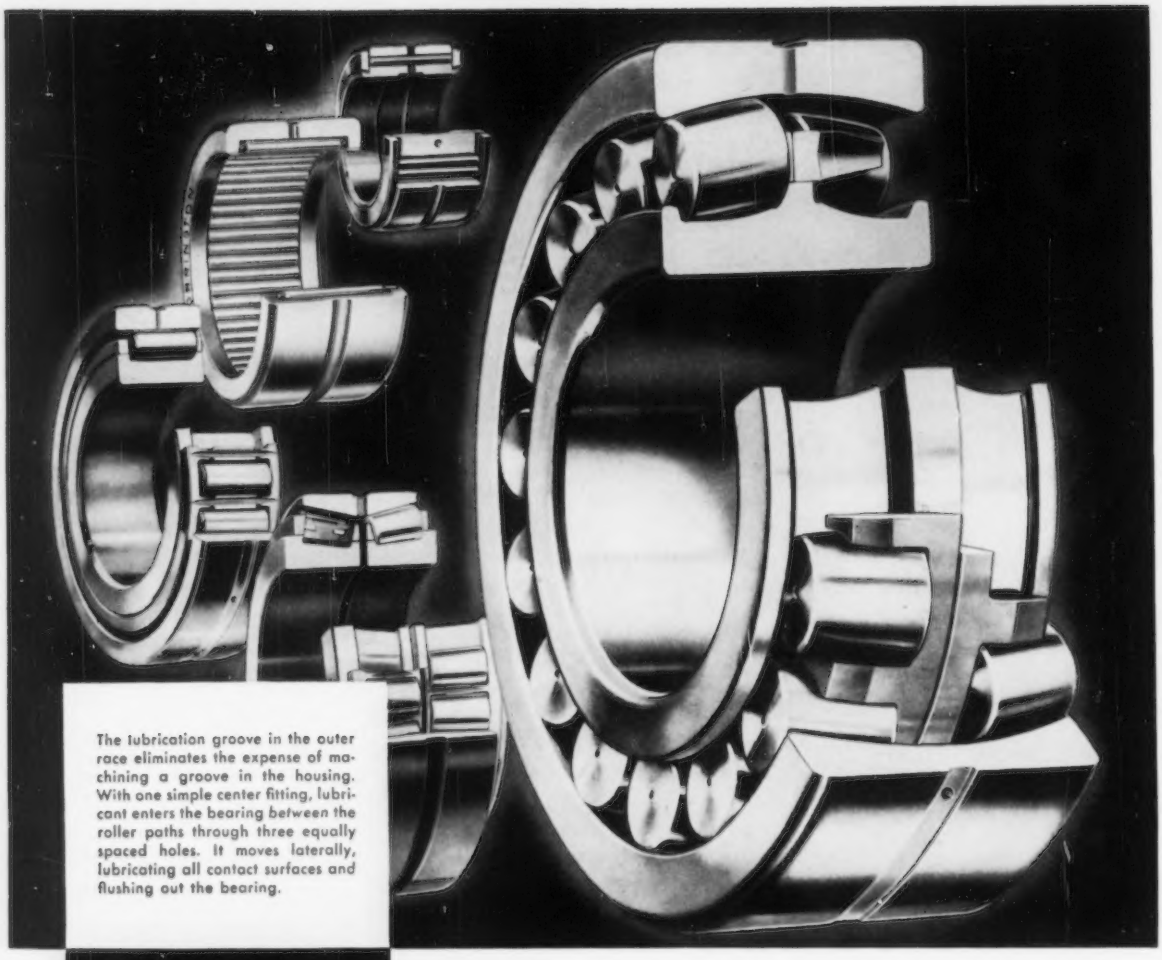
$225,000 in 1951; $40 million in 1958

The Foundation is entirely a federally supported operation. It receives no financial assistance from endowments or other private sources.

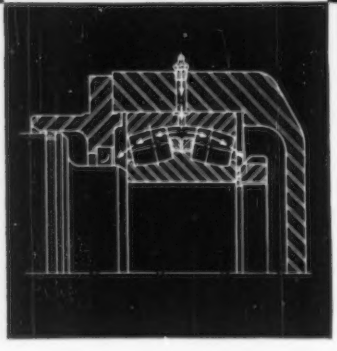
Congress first appropriated $225,000 for the Foundation in 1951. Since then, its annual funds have increased to $40 million for 1958; and $140 million has been asked for fiscal 1959. At no time in the past, however, did Congress give the Foundation as much money as it asked for.

For example, in fiscal 1952-54, the Foundation asked Congress each year for about $15 million. But Congress granted only $3.5 million in

(Continued on page 49)



The lubrication groove in the outer race eliminates the expense of machining a groove in the housing. With one simple center fitting, lubricant enters the bearing *between* the roller paths through three equally spaced holes. It moves laterally, lubricating all contact surfaces and flushing out the bearing.



A time-proved lubricating method now available on Torrington Spherical Roller Bearings

The circumferential groove in the outer race has met the test of experience in many Torrington Bearings, including Heavy Duty Needle Bearings, Aircraft Type Needle Bearings, Tapered and Radial Roller Bearings. Now the circumferential lubrication groove is available in Torrington Spherical Roller Bearings.

This design feature makes it possible to introduce lubricant *between* the roller paths without the expense of machining a groove in the housing. This groove is proportioned to provide generous lubricant flow capacity. Lubricant moves through the roller paths, flushing used lubricant and contaminants away from bearing contact surfaces.

Torrington Spherical Roller Bearings in many sizes may be ordered with this groove as desired at no additional cost. For further information, see your Torrington representative or write: **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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1952, with an increase to $8 million in 1954. In 1955 Congress increased NSF's appropriation to $12.5 million—against a $14-million request.

In fiscal 1957, Congress boosted the Foundation's funds to $40 million. Last year, fiscal 1958, it gave the organization the same amount, but it was still $25 million shy of the amount requested. For the future, however, it seems sure that NSF will get pretty much what it asks for in the way of money. Just recently it made a special request for $10 million for the translation fund.

NSF Administrates; Has no Labs

The Foundation functions in a purely administrative capacity, and does not operate any labs or research facilities. Here are some of the things it did during the last fiscal year:

Made 1,000 grants totaling $21.5 million to some 250 institutions in all 48 states, the District of Columbia, Alaska, Hawaii, Puerto Rico, and a small number of foreign countries.

NSF provided partial support for 25 conferences and symposia on specific aspects of science. It supported 96 summer institutes and 16 academic-year institutes for high school and college science teachers. And, it awarded 1,109 fellowships in science.

In addition, the Foundation assists in getting scientific reports published. It spends around $40,000 a year to get some 15 to 20 Russian technical journals translated. It works with the International Geophysical Year program and is coordinating the US scientific program for the 1958 Brussels International Exhibition.

NSF and Other Government Agencies

Although Congress specifically made it a duty of the National Science Foundation to "evaluate scientific research programs undertaken by agencies of the federal government," as such, the Foundation does not formally review or pass judgment on programs of the Army, Navy, Air Force, or Atomic Energy Commission.

On an informal basis through interdepartmental, government-agency meetings, however, the Foundation claims to stay abreast of all research activities going on in government, and to weed out any overlapping effort. Just what its actual power in this matter is has never been fully decided. Up to now, however, the Foundation's director, Dr. Waterman, has not chosen to test the matter and try to revamp any agency's programs.

As a collateral duty, the National Science Foundation furnishes staff services to some of the President's special committees, the Committee on Scientists and Engineers, and the President's Science Advisory Board, for example. But, it is not responsible for running the committees.

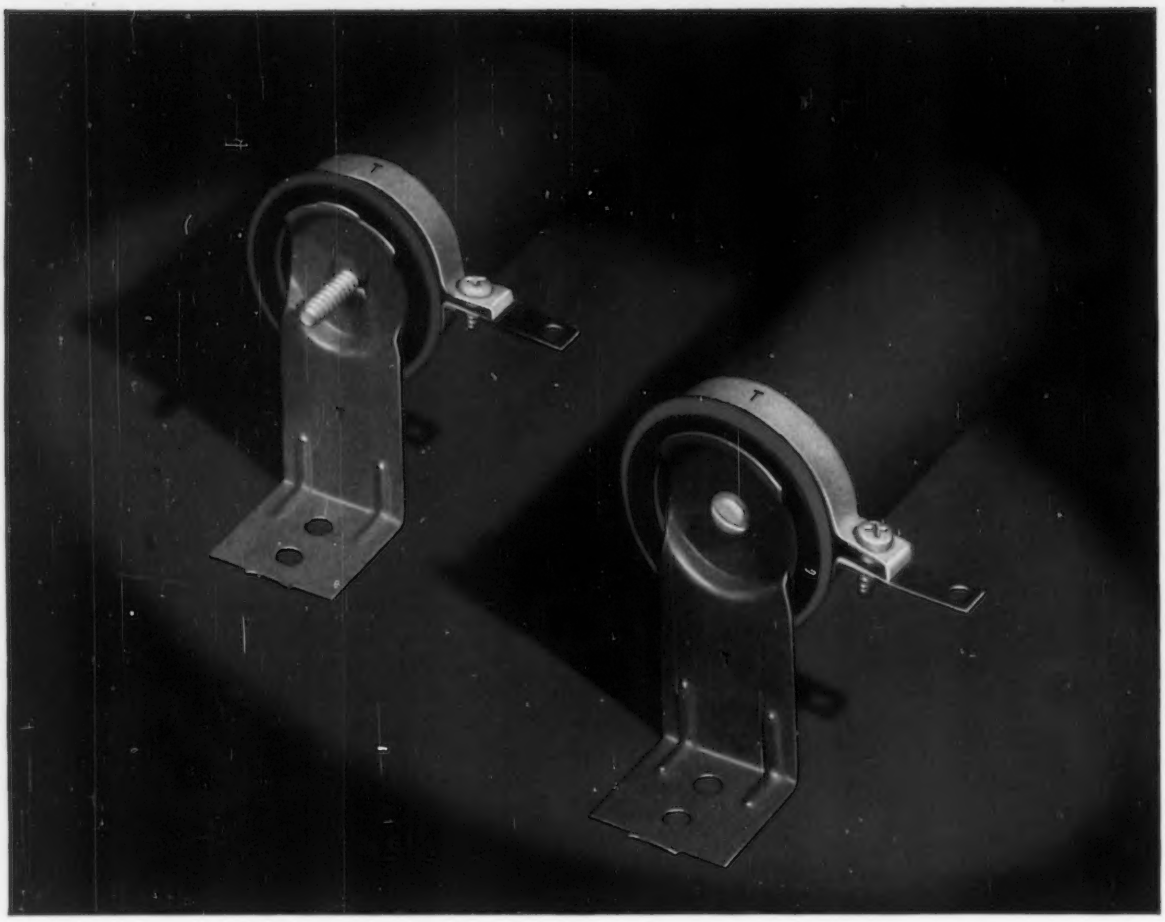
There is no direct relationship between NSF and the National Academy of Sciences—Research Council, or the American Association for Advancement of Science. Both groups are private organizations. Many of their members, however, serve on National Science Foundation panels. Dr. Bronk, President of the National Academy of Science—Research Council is also Chairman of the National Science Board, which governs NSF.

Pro and Con

Critics argue that the Foundation has not provided what Congress intended it to—strong leadership in shaping the government's research programs. NSF supporters, however, say the Foundation is quietly molding the various agency programs into well-balanced research projects; that NSF is too new to crack heads in military departments.

Whatever the past, it seems sure that in future years the National Science Foundation is slated for more money and power in handling the nation's research programs.

—Paul Anderson



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Product Engineering

March 3, 1958

the "HAVE-NOTS" begin to "HAVE"

Some years back, we were taught that there are two kinds of nations, the "haves" and the "have-nots." We were obviously a "have" nation in all respects–men, materials, machines. So were the countries of western Europe, particularly England. The rest of the world was "have-not" in one respect or another. They had no mechanical skill or technical learning. So we had an excellent living assured by selling these backward countries our manufactured products at very agreeable prices.

Then came the series of lessons that we haven't yet learned. Germany challenged twice–and it took most of the rest of the world to beat her. Japan, a very backward, over-populated country of "copyists", suddenly displayed both originality and considerable military skill. Russia, which had been beaten to her knees by one nation after another, has become a tremendous world power. China threw out the last of her warlords. The Near East countries, one after another, have shown the temerity to throw out their "have" bosses from white nations, and now the Far East countries are doing it, too. The African countries are at it as well.

How often must the lesson be repeated before we begin to understand that we have no exclusive control of the world, its ideas–or even of its production capacity? Again and again, the products of foreign research and development challenge us. Again and again, the peoples of "backward" nations use our own skills against us.

Everyone recalls that China was going to collapse because she had gone Communist. Here were 400 million Chinese, most of them poverty stricken, unable to make any modern gadgets for themselves. We resented not so much the collapse of Chiang Kai-shek, but the loss of a potential market for 400 million of all sorts of our products. So we refused to speak to them, to teach them a lesson.

Somehow, they got on without us. *The New York Times* reports that Communist China's trade with USSR rose to $1.5 billion in 1956, three times what it was six years earlier. That was half China's export trade, a quarter of the Soviet Union's. About a quarter of China's export was canned meats, fruits and vegetables, while raw materials were only 16%, animal products 3.4%. Meantime, Russian exports to China of heavy general machinery, textile products, tobacco products, tires, spices and lamp bulbs have practically disappeared because China makes her own. In fact, the export balance now favors China, Russia's big remaining export being petroleum products.

Now, a new report from Hong Kong says China has begun to export diesel engines to Egypt and Syria (an item embargoed by the US for sale to China). She is also exporting rubber tires to Finland, Burma, Ceylon and Syria, textile knitting and other machines, as well as soap machinery, to Indonesia, Egypt and Burma.

Here is cheap labor, working on skilled tasks, to compete for markets on products we thought we alone could make.

It becomes more and more obvious that we shall have to fight for our economic life even if no active war develops. Chances are good that world–and space –supremacy will be determined on the basis of superior research and development. That puts the responsibility squarely upon the engineers to compensate for our higher costs by keeping our products continuously ahead of those available elsewhere at lower prices. And it puts the responsibility upon our other citizens to understand–at last–that we are world leaders only as long as we all work together to be.

fluidizing

NYLON-CLAD

Here's information you'll want as follow-up to our evaluation of nylon-11 two months ago. Tests show the practical value of this new, moisture-resistant nylon as a cladding for metal sleeve bearings.

D. L. PENNEY, *Asst. Professor, ME*
F. J. BOCKHOFF, *Asst. Professor, ChE*
Fenn College, Cleveland

The new polyamide, nylon-11 (*PE*—Dec. 23, '57, p. 6), is showing itself to have a bright future as a cladding for metal sleeve bearings. Nylon-11 offers a bearing surface that will take high load, needs no lubrication, can be turned out at low cost, and will stand up to moisture better than other nylons can—the outstanding advantage of this new polyamide. It offers a superior bearing surface in autos, appliances and farm equipment. Additional advantages come from the way it is applied to metal—by the fluidized powder technique (*PE*—Jan. '57, p. 140).

Already metal bearings clad with nylon-11 are in developmental use in farm machinery and auto steering ball joints. Performance under fatigue tests and in service promise advantages over both molded nylon bearings and metal sleeve bearings with nylon slip liners. Nylon bearings are widely applied because of low friction, wear and cost; but face limitations from dimensional instability caused by moisture, poor heat dissipation which limits the operating temperature and, with slip liners, difficulty in holding close tolerances because of the two-part construction involved.

WHERE NYLON-11 EXCELS

Tests show these problems are eased on aluminum sleeve bearings integrally clad with fluidized nylon-11:

- The material has low moisture absorption, varying from 0.5% to 1.1% under equilibrium conditions—compared with about 4% for other nylons. This low value can be reduced further by quenching the hot, newly coated metal bearing in oil rather than water.
- Coatings meet a wide operating temperature range ranging from a top temperature of 212 F to −67 F. Prolonged no-load overheating to 284 F can be tolerated, and the high specific heat tends to reduce temperature rise. The 50-F spread between fusion and degradation temperatures further reduces the chance of damage to the lining.
- For high-clearance sleeve bearings, fluidizing conditions can be controlled closely enough to give coatings that do not require subsequent machining, and that can take relatively heavy loads under both continuous and intermittent duty.

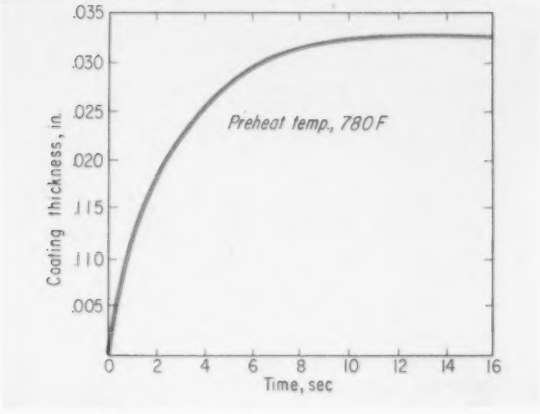
THE CLADDING METHOD

Key to producing satisfactory nylon-clad bearings is the fluidizing process that applies the coating. The aluminum sleeve is heated above the melting point of the nylon, and immersed in a bed of powdered nylon through which compressed air is blown to fluidize the powder. The sleeve is then removed and residual heat levels the adhering nylon particles into a smooth, nonporous cladding. When fusion is complete, the coated bearing is quenched in water or oil to prevent subsequent degradation through oxidation. Coating thickness depends on the ratio of bearing weight to surface area, preheat temperature, and time of immersion.

Effectiveness as a bearing surface depends on the bond set up between the plastic film and base metal. Adhesion of nylon-11 to aluminum is aided by the oxide film on the metal, giving tensile adhesion strength up to 5000 psi. Torsional shear strength is about 2300 psi, with failure occurring at the nylon-aluminum interface. These values are high enough to prevent separation

process gives . . .

SLEEVE BEARINGS



Immersion time . . .
in fluidized bed of nylon-11 powder controls cladding thickness on preheated aluminum sleeve bearing.

between coating and sleeve at any temperature up to bearing failure.

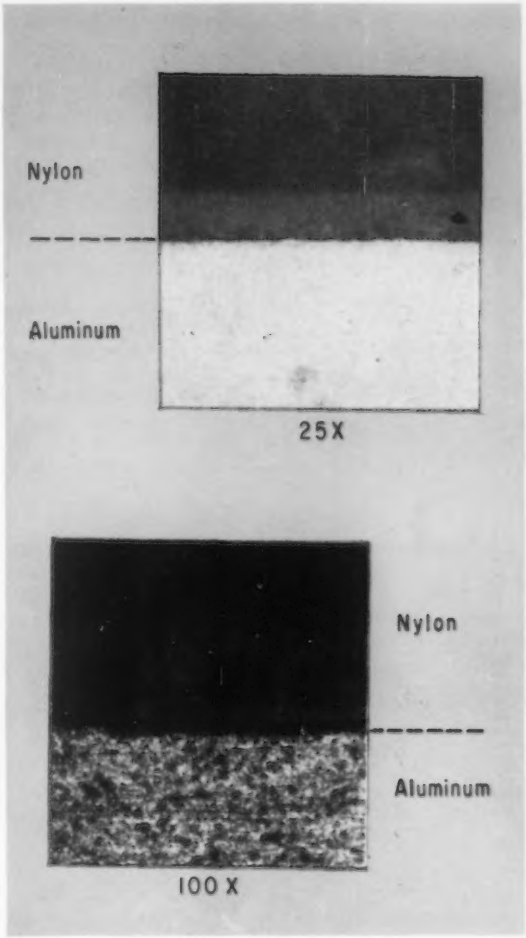
Nylon shrinks on cooling, setting up considerable residual stress–about 1900 psi, calculated from stripped liners. Annealing in an oil bath will remove these stresses, but prestressing is better if temperature buildup is expected–because the heat then goes toward relieving stress rather than degrading the film.

BEARING PERFORMANCE

Allowable loads and speeds for nylon-clad sleeve bearings depend on the coating thickness and bearing clearance–factors that control bearing temperature rise. Bearing tests at various loads and speeds provide a convenient method for checking heat build up.

Temperature-rise data for different thicknesses and clearances are usually plotted against *PV*, product of load per sq in. of projected area (psi) and linear surface velocity of the shaft (ft/min). Long-term endurance tests determine the max *PV* product that can be tolerated without overheating the bearing. Top *PV* values for design are then established by applying an appropriate safety factor. For nylon-11 coatings on aluminum, a max *PV* product of 2000 for continuous duty has been established; for intermittent duty, *PV* may increase to 8000.

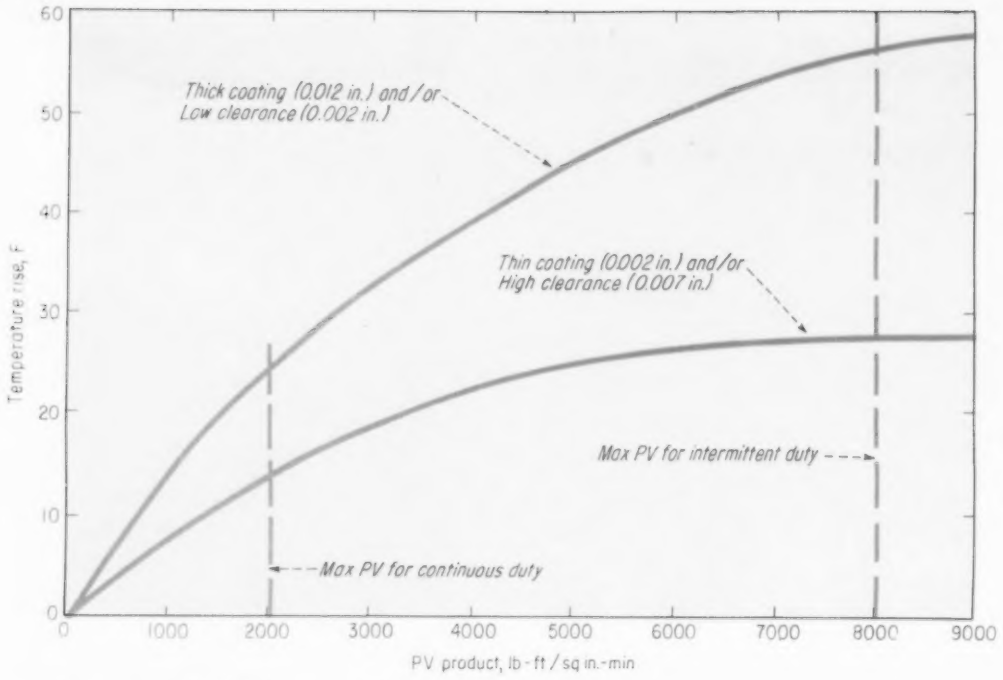
From the allowable *PV* products and temperatures, design loads and speeds can be determined for any



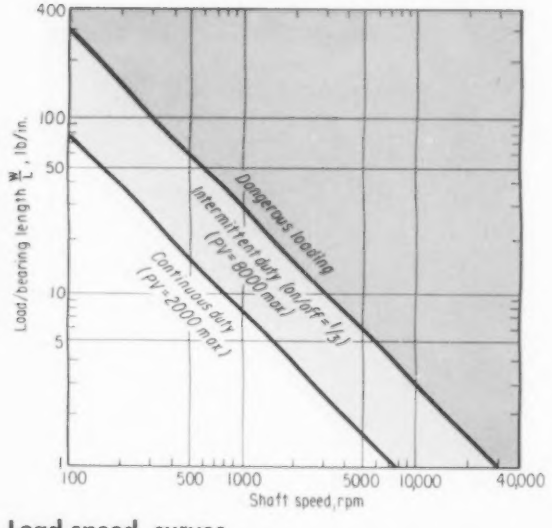
Tenacious bond . . .
forms between nylon and aluminum after bearing is removed from fluidized bed and residual heat is allowed to fuse clinging powder into a smooth, nonporous film.

application. The basic expression for allowable load in a sleeve bearing is $W/L = 3.83PV/n$

W = lateral load on bearing, lb
L = length of bearing, in.
n = shaft speed, rpm
P = lateral pressure on projected area, psi
V = surface velocity of shaft, ft/min



Bearings get hotter . . .
when nylon coating is thick and clearance is low. Limiting *PV*-values, product of lateral projected area pressure *P* and shaft surface velocity *V*, are established by long-term endurance tests. Here, bearing temperature would be expected to rise 10-15 F for continuous operation; intermittent service would give a 28 to 57-F increase above ambient. An initial light film of oil is necessary for these ratings. Bearings here were bored to ½-in. I.D.



Load-speed curves . . .
based on limiting *PV* products for ½-in. ID test bearings, apply to nylon-coated sleeves of any size.

EDITOR'S NOTE: Nylon-11 in powder form especially modified for fluidized coating, along with the necessary equipment for applying it, can be obtained under the tradename of AGILON-1056 from American Agile Corp, Bedford, Ohio.

PROPERTIES OF NYLON-11 FLUIDIZED COATING

Specific gravity	1.04
Melting point	356 F
Specific heat	0.58 cal/gm
Water absorption, 14 days	1.6%
Dielectric Strength, 0.120[11]	450 v/mil
Coefficient of friction (steel)	0.11–0.18

This relation is plotted in the chart on this page for nylon-11, using max allowable *PV* values for both continuous and intermittent bearing operation. Diameter of the shaft cancels out in the *PV* product, and the curves are independent of bearing dia, so tests on bearings of one dia can establish design criteria for bearings of all sizes. The region above the two curves should not be used for design.

A quick method of checking on the selected allowable *PV* values is by short-time failure test. The bearing load and/or speed is slowly increased until failure occurs. For nylon-11 linings on aluminum, the *PV* product averages 21,700—well above the selected safe value of 8000 for intermittent service. Bearing failure is accompanied by excessive vibration, or by heat distortion enough to shift the nylon lining. In no test, however, does the nylon-aluminum bond fail; a thin coating of nylon remains on the entire bearing surface.

LINEAR PROGRAMMING can be EASY MATH

Electronic computers? Complex equations? Just pencil, paper and simple arithmetic will chart the answer when the problem is a transportation type (which needn't involve actual transportation at all). In a sample problem the author shows you how.

GEORGE F. HADLEY
School of Industial Management
Massachusetts Institute of Technology

The practical appeal in a transportation-type problem (which occasionally has little or nothing to do with actual transport) is that it can be set up to give a cost or productivity answer—with all the advantages of linear programming, but without need to get involved with electronic computers and techniques of advanced mathematics.

Suppose you want to figure the least costly schedule for shipping a product from several warehouses to several retail outlets. Here is a linear-programming problem which falls into the transportation group and is made to order for simple solution with pencil and paper—so simple the problem can be handled by clerks with little or no technical knowledge. The only arithmetical operations needed are addition and subtraction.

But suppose a company makes a number of different products involving a simple operation on any one of several company-owned machines. Naturally, production costs will vary, depending on machine used and product made. Here too, if setup times are negligible, minimum production costs can be found from transportation-type equations.

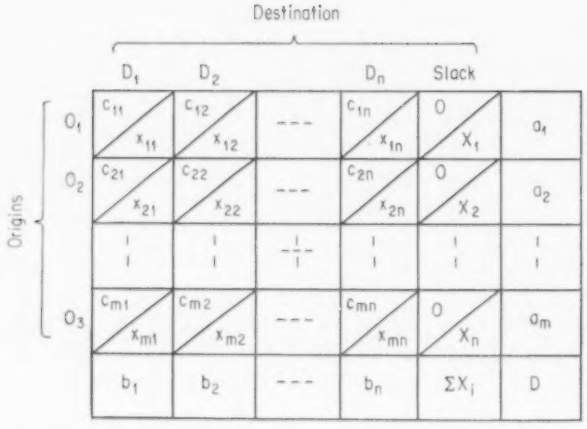
WHEN IS IT TRANSPORTATION TYPE?

Of the wide variety of problems that can be formulated to give transport-type solutions, easiest recognized are those dealing directly with moving a product. In the petroleum industry, for example, this linear-programming shortcut will determine optimal transportation schedules from a number of production regions to various refineries.

The method will also solve slightly more complex problems involving actual transport—for example, when there is not only a variable shipping cost between a number of plants and warehouses, but when manufacturing costs at each plant vary too. In formulating this problem, transportation cost is simply redefined to include cost of production at a given plant, plus cost of shipping to a given warehouse.

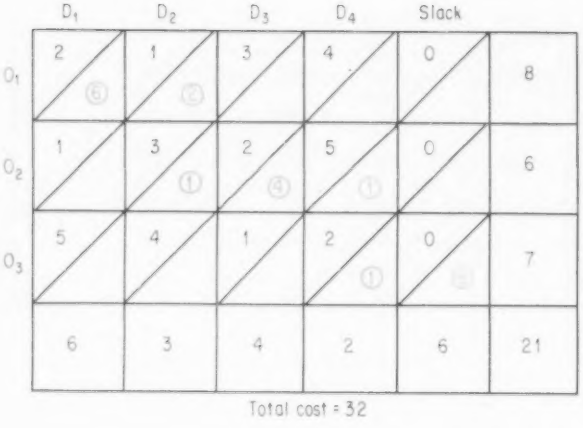
Production scheduling problems often can be set up the same way. For instance, sales of children's toys show a seasonal fluctuation—Christmas sales are many times larger than sales during the rest of the year. When production attempts to follow this pattern, there are large overtime charges in the months preceding Christmas and less-than-capacity operations during other months. And if production is made uniform, storage charges build up. The optimum production schedule giving minimum cost of production and storage can be found. Again, tranport-type equations give a quick-and-easy answer.

In the same way, the so-called personnel assign-



Tabular matrix . . .

allows convenient manipulation of variables in a transportation-type problem, aiding iterative solution. Quantity shipped from origin O_1 to destination D_2 is therefore shown as x_{12} and entered in lower part of square at intersection of row and column. Cost of shipping one item from O_1 to D_2 is entered in upper corner of square as c_{12}. Slack remaining at origin is relegated to slack column at right. Quantities shipped from each origin plus slack are summed at extreme right; total shipped to each destination and total slack are summed in bottom row. Sum of total shipped plus slack equals sum of available units and is shown as D in lower right-hand corner. To find total shipping cost, multiply x factors by associated cost and add products of multiplication.



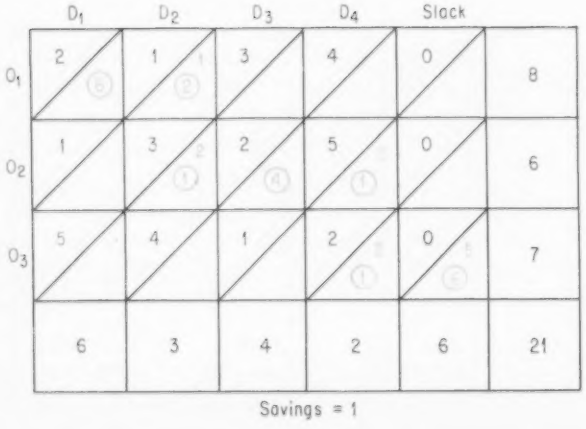
Total cost = 32

First iteration . . .

of sample problem shows method of manipulating variables. Known are: quantity available at each origin—entered at right; quantity required at each destination—at bottom; and shipping cost from each origin to each destination—in upper corner of appropriate cell. Total slack, 6 units, equal quantity available minus quantity shipped.

Initial solution is found applying the "Northwest Corner" rule. Starting in upper left-hand square, 6 units are entered, meeting requirements at D_1. Two of the 8 units available at O_1 remain and are sent to D_2. D_2 requires 3 units, however, so one additional unit is sent from O_2. In same manner, 4 units are sent from O_2 to D_4 and the remaining unit at O_2 sent to D_1. One unit is sent from O_3 to D_4 leaving 6 unshipped at O_3. It is convenient to circle these values to avoid confusion with later entries.

All requirements are satisfied and only $m+n$, or 7, x_{ij} terms are different from 0. This, then, represents a workable solution but not necessarily an optimum. Total cost is $12+2+3+8+5+2=32$.



Savings = 1

Second step . . .

evaluates effect on total shipping cost when preliminary approximation is altered. One unit is injected into one of the blank squares and the table is rebalanced.

If, for example, 1 unit of slack is introduced at O_1, 1 unit must be subtracted from 6 units of slack at O_3 to meet requirements for total slack. One unit must then be added to cell O_3D_4 to meet row requirements at O_3. Similarly, one unit is subtracted from cell O_2D_4 to satisfy column-sum at D_4. Row-sum O_2 is then short and must be adjusted by adding one unit to cell O_2D_3 or O_2D_2. It is impossible to change O_2D_3 because its column-sum is already fulfilled. One is therefore added to cell O_2D_2 and 1 subtracted from O_1D_2. O_1 row requirements are now satisfied because of slack introduced in the initial step and the table is again balanced.

Note that method here is successive introduction of 1 unit at each point where x_{ij} is 0. Only circled values are changed to satisfy the table sums.

Summing costs reveals that introducing slack at O_1 saves 1 cost unit. This process is repeated until cost savings have been evaluated for each blank cell.

ment problem is often a transport problem. Here, a number of persons are available in several personnel categories, and a number of jobs are open in several job categories. When productivity of each person at each job is known, formulation gives transport-type equations—except that here the result is to be maximized, not minimized.

SETTING UP THE PROBLEM

The shipping-cost problem mentioned first above (and solved in accompanying tables) will serve as guide for formulating the others. Suppose there are m origins (warehouses) and a_i units of a uniform product available at origin i. Also, there are n destinations (retail outlets) requiring b_j units of the product at outlet j. Let c_{ij} be the cost of shipping one unit of the product from i to j. This will be assumed to be minimum cost for shipping a unit from i to j. Let x_{ij} be the number of units shipped from i to j. The total shipped to all destinations from i cannot be greater than quantity available a_i:

$$\sum_{j=1}^{j=n} x_{ij} = x_{i1} + x_{i2} \ldots + x_{in} \leq a_i$$

Similarly, the total shipped from all origins to j must be b_j:

$$\sum_{i=1}^{i=m} x_{ij} = x_{1j} + x_{2j} \ldots + x_{mj} = b_j$$

And minimum total cost can be expressed:

$$\text{minimize} \quad \sum c_{ij} x_{ij}$$

There are m origins and n destinations. Each origin can ship to n different destinations. Each destination, in turn, can receive products from m different origins. There are, therefore, mn variables x_{ij} and $m+n$ constraints. Variable cannot be negative.

In any constraint equation, the cofficient of each x_{ij} is unity. Furthermore, each x_{ij} appears in only two constraint equations. These two properties account for the formulation that gives simple solution to the transportation problem. By contrast, general linear programming problems allow a given variable to appear in all the constraint equations and to have different (and arbitrary) coefficients in each constraint.

THE SOLUTION

It is always easier to work with equations than with inequalities. First step, therefore, is converting inequalities to equations. This is is easy to do. Suppose a new variable called a slack variable is defined, indicating units of product not shipped:

$$\sum_{j=1}^{j=n} x_{ij}$$

Then

$$\sum_{j=1}^{j=n} x_{ij} + X_i = a_i$$

and a set of equations replaces the set of inequalities by adding in slack variables—one for each origin. Units not shipped have no transportation cost, so cost associated with a slack variable is zero.

The solution is now carried out in an iterative way—manipulating variables until the optimum solution is found. Note that no more than $m+n$ variables of x_{ij} need be different from zero in an optimum solution. Hence, only solutions containing $m+n$ variables differ-

	D_1	D_2	D_3	D_4	Slack	
O_1	2 (5)	1 (2)	3 -3	4 -1	0 1	8
O_2	1 3	3 (1)	2 (4)	5 (1)	0 3	6
O_3	5 -4	4 -4	1 -2	2 (1)	0 (6)	7
	6	3	4	2	6	21

Cost savings . . .
effected by introducing 1 unit in each blank cell are inserted in their respective cells. Savings are positive; cost increases are negative.

Three cost units will be saved when 1 unit is entered in O_3D_1 or slack at O_2. There is a tie here; both factors result in same saving. In such cases an arbitrary choice can be made. Suppose cell O_3D_1 is chosen. To minimize cost, it is desirable to introduce as many units here as possible. But only 1 unit in O_3D_1 drives O_3D_2 to 0 indicating that 1 unit is the maximum which can be entered here at present.

	D_1	D_2	D_3	D_4	Slack	
O_1	2 (5)	1 (3)	3 0	4 2	0 4	8
O_2	1 (1)	3 -3	2 (4)	5 (1)	0 3	6
O_3	5 -7	4 -7	1 -2	2 (1)	0 (6)	7
	6	3	4	2	6	21

Total cost = 29

New solution . . .
saves 3 cost units. But solution is not yet optimum. Blank squares are evaluated as in first iteration showing that introduction of 1 unit in slack column at O_1 will save an additional 4 cost units. Iterations are repeated, introducing this variable first, until optimum is reached.

ent from zero are considered. The steps are

1. With $m+n$ variables, find a workable solution which satisfies the equation. The "Northwest Corner" rule is the most methodical. But, with practice, a clerk can learn to spot low shipping costs and bring them immediately into this first solution.

2. Solution is modified, changing one variable at a time, to determine which variables, if any, improve the result.

3. Variable which improves result is included in solution in as large a quantity as possible.

Steps 2 and 3 are repeated until a change in any of the variables does not improve the result. Manipulation of variables is aided by a tabular matrix and the optimum solution can be reached in a finite number of steps using only simple arithmetic.

EDITOR'S NOTE: Compared with the transportation approach, the simplex method, "Too Many Solutions," Oct 14 '57, p 93, will solve any linear-programming problem, but requires computers and techniques of advanced mathematics.

Another aspect of Operations Research, of which Linear Programming is a part, is Queueing Theory. "Queueing Up," Nov '55, p 188, discusses the theory of waiting lines and its application to industry in assuring smooth flow of materials from input to output.

"Operations Research Takes a Look at Itself," Dec 2 '57, p 36, shows in tabular form who is using O-R, and how well it has worked.

	D_1	D_2	D_3	D_4	Slack	
O_1	2 (ε)	1 (3)	3 −2	4 −2	0 (5)	8
O_2	1 (6)	3 −3	2 −2	5 −4	0 −1	6
O_3	5 −3	4 −3	1 (4)	2 (2)	0 (1)	7
	6	3	4	2	6	21

Total cost = 17

Optimum solution . . .
is achieved by repeated manipulation of the variables. No further reduction in cost is possible because each noncircled cell shows a negative number. Introduction of 1 unit in any cell will only increase cost.

However, just previous to this solution, not 1, but 2 variables (O_2D_2 and O_1D_1) were driven simultaneously to 0. The solution now has only 6 variables different from 0. This is called degeneracy; and is eliminated by allowing one of the variables which was driven to 0 to remain in the solution.

The choice is arbitrary. If cell O_1D_1 is chosen, an ϵ is placed in the cell. The ϵ can be considered a very small positive value and units may be added to it or subtracted from it as though it were actually in the solution. Subtraction, of course, results in a $(\epsilon - 1)$ term—obviously not realistic. Such a term could only be inserted where evaluation of an unknown cell was required and a feasible solution was not the goal.

Degeneracy can occur anytime in the course of the problem. It can occur in several places. In any case, the ϵ terms are retained until an optimum solution is reached. They are then set equal to 0 again.

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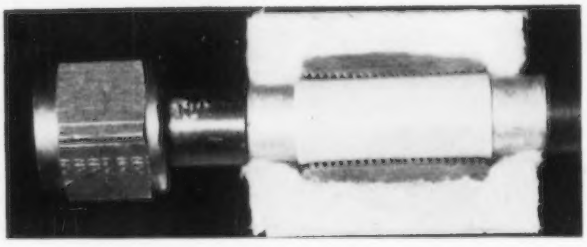
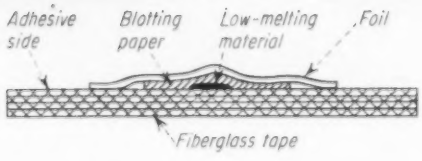
one way to MEASURE TEMPERATURE of HYDRAULIC LINES

J. H. FAMME
Assistant Chief Engineer
Convair, San Diego



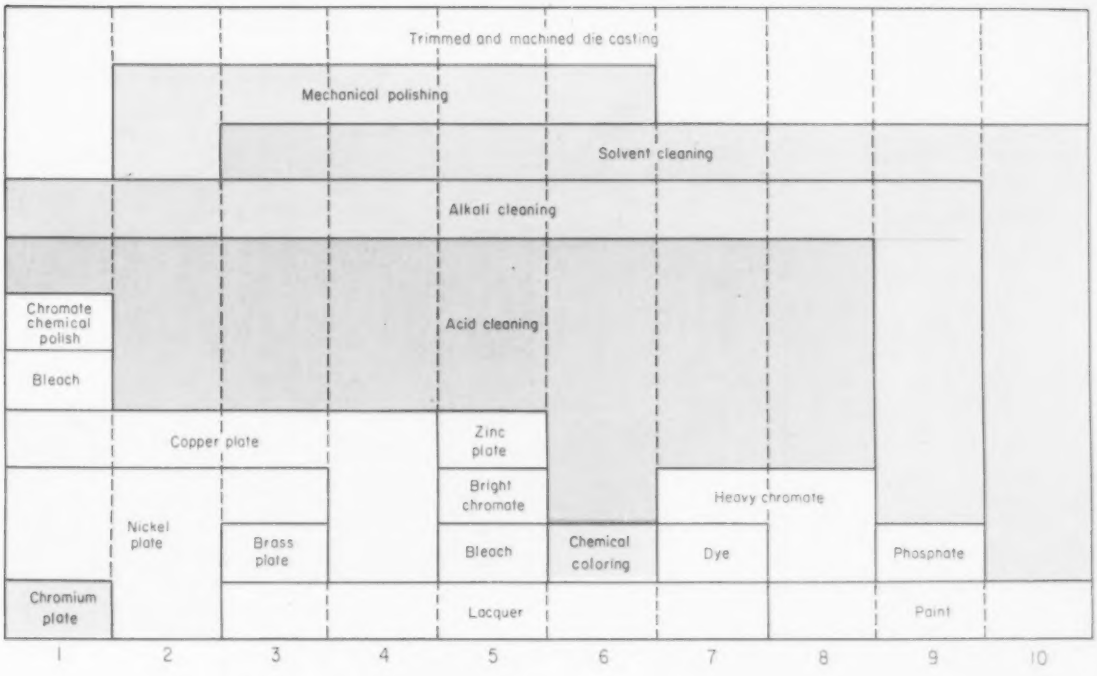


Temperature and duration of heating can be measured on inaccessible parts by a pressure-sensitive tape applied as a bandage. Idea uses a small piece of a material that melts at the expected temperature, in combination with a small heat sink—all held to the part by a piece of pressure-sensitive fiberglass tape.

For temperatures up to 500 F, the melting material can be Tempilac or Thermopaper, both commercially available in a range of melting points. A small piece is placed on a slightly larger piece of blotting paper and both are applied to the adhesive face of a still larger piece of tape. The blotting paper is protected with aluminum foil, and the entire "bandage" is taped to a surface being heated—such as this hydraulic line.

The heat barrier introduced by the blotting paper provides a small heat sink. Longer time delay can be introduced by enclosing the bandage with a split metal bushing. Thermal insulation on the outside of the bushing will have the effect of reducing the time delay. In the construction shown here, equilibrium temperature was reached in about 20 min.

Available materials cover the range from 113 to 500 F, giving max temperature indication about 10 to 15 F below actual. Difference between surface-temperature indication and actual temperature of the heat sink bushing provides a basis for estimating the duration of the surface temperature. For rapidly fluctuating heat the tape will indicate mean temperature.



which finish for Zinc Die Castings

Skimp on the last step and the casting isn't a quality part. Overdo the finishing, and you lose the economy of zinc die-casting. Here's a guide to mechanical, chemical, plating and painting methods.

RAY STRICKLEN

Product Director
Allied Research Products, Inc.

Why Coatings?

They add resistance to corrosion and wear; at the same time they give a choice of decorative finishes. Although suitable for many purposes without any finish, zinc tarnishes quickly—forming a thin gray film. This lowers "eye appeal." And if oxygen is limited, a bulky, white spongy material results—which rapidly corrodes the zinc and interferes with operation of moving parts. Alternate wetting and drying is particularly harmful because it accelerates such corrosion. Suitable coating is the preventive.

The chart above was prepared to help give a fast answer to a major problem when designing with zinc-base die castings. That problem is economy. The chart is a guide to 10 finishing processes. It shows at a glance the number of preparation steps needed for a given finish. For example, simply painting the part (process 10) may need only two preparatory steps—trimming and machining the part, then cleaning it with solvent. On the other hand, if zinc plating is required (process 5), five preceding steps are necessary—and two more if the plated part is then to be lacquered.

Economy must not, of course, dispense with necessary mechanical properties and "eye appeal" (covered in the table on following page). But these should be obtained at minimum expense because a big reason for the popularity of zinc is its relatively low cost. This should not be offset by unnecessary finishing steps.

Moreover, the nature of the step itself may affect economy. Certain shapes drain poorly if an immersion process is used; other shapes have recesses too deep to permit electroplating in solutions with poor throwing power. Therefore: Design parts so decorative areas are sound, with little surface porosity. Break up continuity of large reflecting surfaces so defects are less noticeable. Add beads at parting lines to facilitate flash removal and hide mold mismatch (May '57, p 190). Excessive use of lubricant during die casting will require extra cleaning—so will certain binders used in polishing.

Expected life also determines the choice of finish, and therefore the cost. Both metal and nonmetal finishes are available in wide ranges of durability under adverse conditions—from a few months' shelf storage

BASIC DATA ON **FINISHES FOR**

TYPE OF FINISH	Purpose				Appearance				Resistance to				Preparation Required				Application Methods		
	Final Finish				Clear		Colors												
	Decorative	Protective	Paint Bonding	Preparation for plating or chemical finish	Unpolished	Bright	Basic Color	Others	Weathering	Humidity	Salt Spray	Wear	Buffing or Chemical Polishing	Solvent Cleaning	Alkali Cleaning	Acid Cleaning	Immersion	Brush	Spray
MECHANICAL																			
Polishing & buffing				x		x													
Tumbling & burnishing				x	x	x													
Sand, shot & grit blasting			x	x	x														
CHEMICAL																			
Chromates																			
Light	x	x	x	x	x	x			fair	fair	fair	poor			x	x	x		
Medium	x	x	x				Yel. O.D.	x	fair	good	good	poor			x	x	x	x	x
Heavy	x	x	x				Br.	x	fair	good	good	poor			x	x	x		
Phosphates		x	x				Grey		fair	fair	fair	poor			x	x	x	x	x
Blacks based on nickel or molybdenum salts	x						Blk		poor	poor	poor	fair			x	x	x		
ELECTROPLATING																			
Zinc	x	x			x				poor	poor	poor	poor			x	x	x		
Zinc & chromate	x	x	x			x			fair	fair	fair	poor			x	x	x		
Copper-nickel-chromium	x	x				x			fair	fair	fair	good	x	x	x	x	x		
ORGANIC																			
Lacquers, enamels, paints	x	x			x	x	All		good	fair	fair	good			x Plus chemical treatment	x	x	x	x

to years. Sometimes a thicker coating of the same material will extend life more cheaply than by adding another coating layer. On the other hand, an excessive thickness of direct nickel plate will crack in service.

Some metal finishes require additional transparent coatings to maintain appearance; and coatings gain extra durability when preceded by a chemical conversion treatment—this provides a paint bond and prevents the corrosion that undercuts and peels the coating.

MECHANICAL FINISH

Zinc die castings all require some trimming. Flash at the die parting must be removed and if this trimming can be combined with mechanical finishing several steps are eliminated. However, a mechanically finished surface will tarnish more easily than an unpolished one and so should be only a preparatory step for other finishes. When high luster is desired, buffing and coloring is required; when a satin finish is acceptable, tumbling is more economical and removes flash too. Grit blasting is cheap, and a prepaint step, but leaves surface too rough to cover with a single coat.

ELECTROPLATED FINISH

Electroplates applied to other metal products also work with zinc die castings but some change must be made in bath formula and method of application. The copper-nickel-chromium combination is by far the most common. For this coating, first give a strike coating of copper. Follow it with a deposit of soft nickel, then a flash coating of chromium. The copper must be at least 0.0002 in. to prevent the entire copper layer from diffusing into the zinc and spalling the electroplate on top. The soft nickel plate is bright, needs no buffing and levels small surface imperfections such as lines left by buffing.

Nickel-plating solutions for coating zinc directly are available but generally give brittle deposits which are not bright. Chrome plate prevents tarnishing of the nickel and adds wear resistance. Instead of chrome, deposits of brass, silver, or gold may be plated for decorative affects. These are nearly always followed by lacquer for wear resistance.

A relatively low-cost finish with good appearance results when the die casting is zinc-plated and given a

ZINC DIE CASTINGS

Relative Cost			Government Specs. Available	Special Properties and Remarks
High	Medium	Low		
x				Remove flash and surface defects
		x		" " " " "
	x			Typical matte surface
		x		Clear to pale iridescence
		x	x	Iridescent yellow Some may be bleached
		x	x	Dark bronze to olive drab No decorative finishes
		x	x	Used as paint base only
		x		Decorative only No appreciable protective value
	x	x		Untreated zinc plate tarnishes rapidly
	x	x		Supplementary treatment for zinc plate
x				High quality decorative finish. Nickel thickness must be adequate if extended outdoor life is expected
x			x	

chromate conversion treatment which polishes and passivates the surface. This treatment gives a light yellow and iridescent coat which can be bleached in mild alkali to approach bright chromium in color. Lacquer increases durability to equal that of conventional chrome plate for decorative service such as in automotive trim. In some cases, to prevent a blue-gray discoloration, a flash plate of copper, or brief etch in sodium zincate solution, must precede zinc plating.

Instead of electroplating, the die casting may be chemically polished to a luster acceptable for many applications. This operation, a chromate conversion type, is usually bleached to a clear finish. The finish is superior to zinc plating because, like other electroplated finishes, zinc does not deposit uniformly in recesses and leaves areas without adequate protection. Chemical polishing and the accompanying passivation reaches all areas uniformly and the durability may exceed that of chromated zinc plate by as much as 3 to 1. Again clear lacquer increases protection to corrosion and gives wear resistance.

When the die casting has a high-quality surface, and close trimming eliminates need for grinding, chemical polishing may be a money-saving substitution for buffing. After bleaching, parts are then plated conventionally. The final finish after chromium plating varies slightly in texture from that produced on a buffed die casting, but the luster is acceptable for most decorative applications.

CHEMICAL SURFACE CONVERSION

Chemical conversion treatments like the chromate phosphate or chemical coloring treatments can by themselves provide a finished surface but are more often a base for other coatings. The phosphate treatment increases long-term paint adhesion and the chromate gives superior corrosion resistance in severe exposures. Both help prevent corrosion from working under paint or other organic coatings and forming blisters.

The chromate coatings are recognized by their iridescent yellow or olive-drab color and can be dyed various colors. Clear lacquer here increases wear resistance.

After chemical cleaning, the die castings can be given a direct chemical coloring, such as those based on molybdates or nickel salts, to give a black finish. These coatings also require a lacquer. Its purpose is to add corrosion protection.

ORGANIC FINISHES

Organic finishes offer the widest selection of colors and lusters. Paints can be applied directly to the bare zinc die casting but eventually react to form a metallic soap which destroys adhesion of the paint coating. If the coating is scratched, corrosion can occur under the film and spread from the scratch. Both these forms of deterioration can be prevented by surface conversion treatments such as phosphating or chromating. Paints used on unpolished die castings should have good leveling power to cover visible defects.

Lacquers vary considerably in cost and wear protection. The nitrocellulose products are lower in cost; melamines and methacrylates are more expensive; epoxys are the most costly. They give excellent corrosion protection, but are not as hard and wear-resistant as chrome plate.

A variation is to injection-mold a plastic over a zinc die casting. The die-cast core gives strength and the plastic supplies a surface that needs no further finishing.

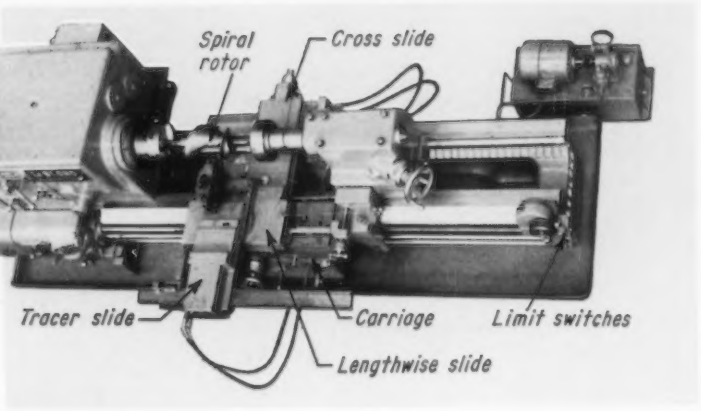
EDITOR'S NOTE: Other articles on designing economical die-cast parts:

"How Design Affects Cost of Chrome-plated Die Castings," May '57, p 190. How to select material; design section thickness, fillets, parting lines and lettering.

"Redesign for Die Castings," Jan '56, p 156. Gives properties of die-casting alloys, methods for strengthening castings and core design to reduce machining.

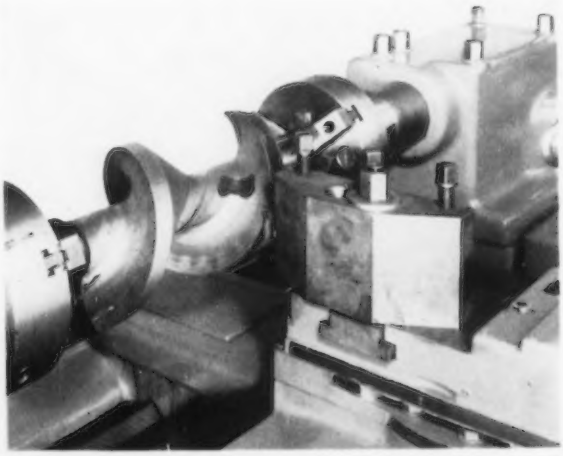
REPRINT of this article can be obtained for your reference file by checking No. E11 on one of the Reader Service cards bound in this issue. For other reprints available see "Current Reprints" listing in this issue on page 127.

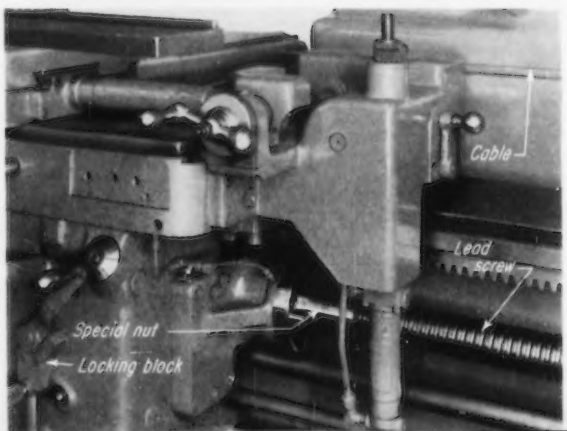
Lathe Cuts Spirals



An unusual tracer arrangement lets an engine lathe cut 3-dimensional contours on spiral-shaped rotors. The tracer doesn't guide the tool along the work, but positions it for successive cuts. Cutting motion is obtained by chasing the spiral as if it were a thread.

Lathe can be converted for general-purpose use by changing gears between spindle and lead screw, and removing special nut and locking block from carriage. The R. K. LeBlond Machine Tool Co., Cincinnati, developed the unit to machine spiral-shaped rotors for Roots-Connersville blowers.





Carriage and spindle . . .

are always synchronized by the lead screw. It drives the carriage through a special extra-long nut to chase spirals with leads from 4½ to 16 in. A standard cross slide is mounted on the carriage and automatically gives in-and-out motion for tool relief on the return stroke. On the cross slide is a special lengthwise slide and the tracer slide that carries the tool. The templet is on the carriage and causes the tool to feed automatically between cuts; no feed occurs when cut is made.

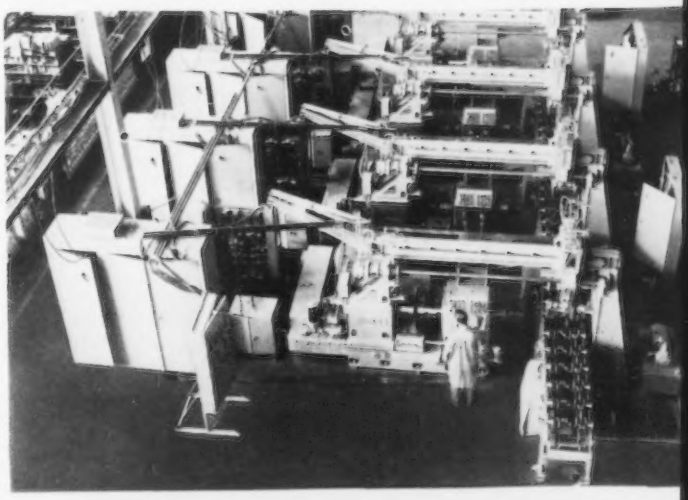
A cable attached to the lengthwise slide actuates limit switches at foot of bed to sequence cutting, feeding and relief motions for automatic cycling. On each successive cut, the carriage moves closer to the headstock and in this manner shifts the templet under the tracing stylus. Previously, shapers generated the spiral rotor surfaces but the straight-line tool motion limited contour variations. Now, using tracer only to feed tool, rotors are machined with convex, concave or compound surface contours.

Work is held by chucks in head and tail stock and is reversed after first surface is machined. A special clamp and locating pin drive the work to prevent shifting after cut is started. For left-hand rotor, tool cuts from headstock to tailstock; for right-hand rotor, from tailstock to headstock.

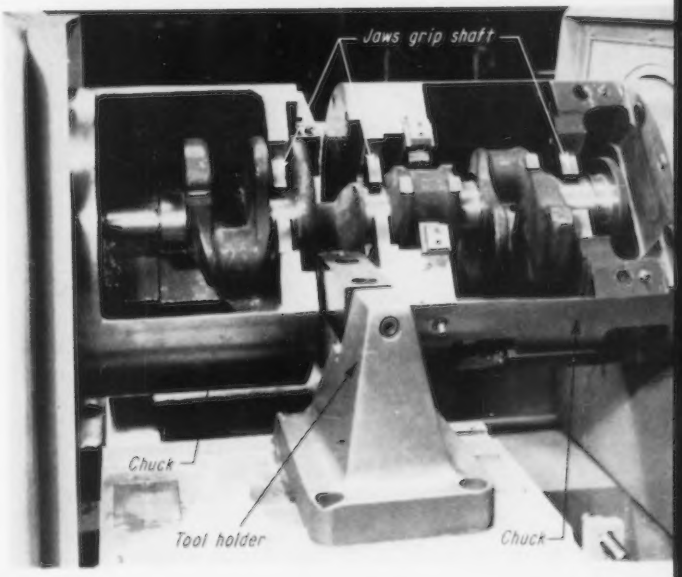
Redesign Speeds Automation

Though automatic, usual method for turning crankpins was too slow. With this transfer machine, production has tripled—thanks to new tools and individual drives for lathes.

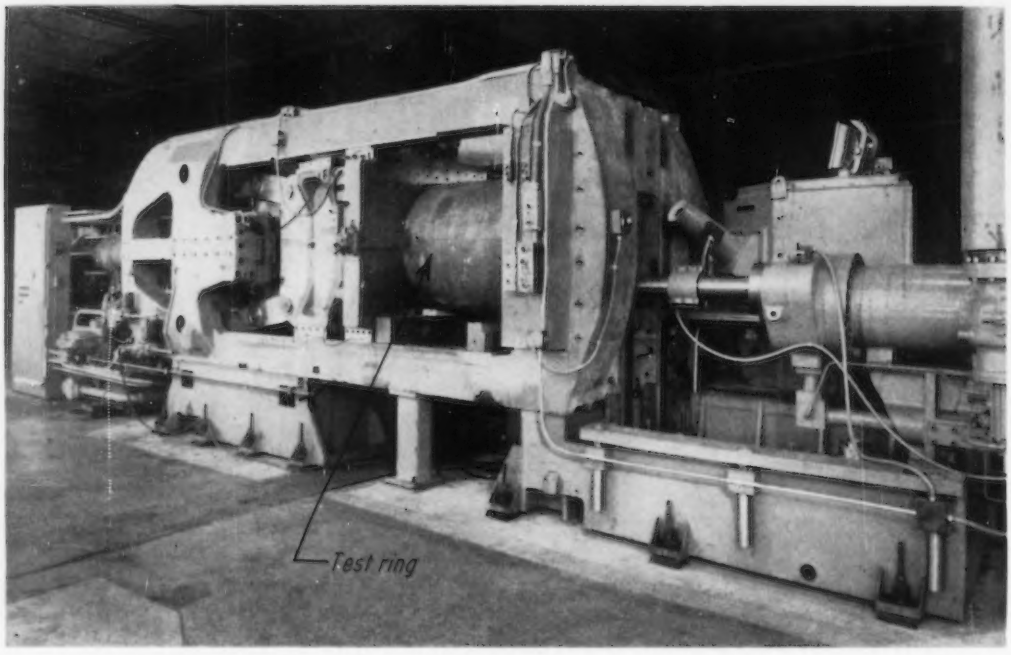
Thirty years ago each pin of a crankshaft was machined in a different lathe set up to turn the shaft about the pin axis. Then came double-spindle lathes in which synchronized master crankshafts generated tool motion for cutting a new shaft—but unbalance limited output to 25 shafts per hour even with the automated handling. Now, machine designed by Machine Tool Div. of Wickes Corp., Saginaw, Mich., combines original method with modern tools and speeds. Output: 50 shafts per hour.



Four crankpin lathes . . . are serviced by a transfer line and progressively machine the pins on shafts for V-8 engines. Although work flows to each lathe in succession, lathes operate independently, can be skipped for adjustment and repair, and have separate controls. Machining pins with separate spindle drives lets motors apply more total power than would be feasible with a common drive. Key to increased production: higher speed obtained with individual drives, special balanced chucks and carbide tools. Crankshafts are picked from transfer line by fingers that move along lathes to load and unload chucks.



Crankshafts are held . . . in special chucks that slide in sleeves in the drive heads to accommodate different shafts. Pin being cut is between chucks and front and rear tools. Shafts are held by finished journals, but rotate about axis of pin being machined. Holders carry special carbide tools that feed into pin simultaneously from front and rear. Jaws that clamp journals are adjusted to shaft dimensions when machine is set up. Shafts are loaded and unloaded automatically.

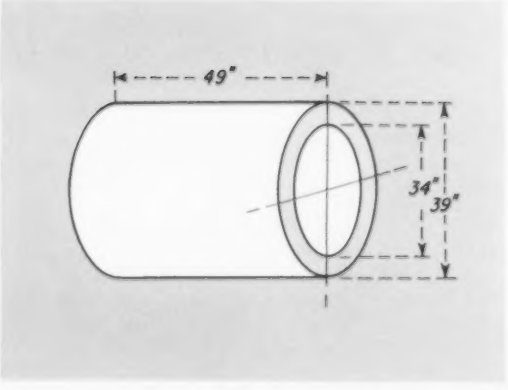


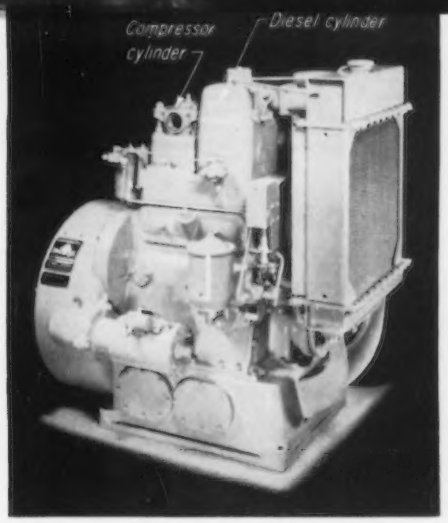
Test Ring Rates Casting Machine

The clamping tonnage of this die-casting machine is rated with a test ring having structural properties like those of a die. Twelve pairs of SR-4 strain gages, spaced around the inside surface, show clamping force on an electrical strain indicator.

Ring was first calibrated in a universal testing machine at National Malleable Casting Technical Center. Installed at Johnson Motors, Waukegan, Ill., this 1200-ton machine casts up to 47 lb of aluminum in one shot and will cast blocks and housings for Johnson's new line of V-type outboard motors. Made by Lester-Phoenix, Inc., Cleveland, machine is largest built with one-piece frame. Frame and die platens were cast in Germany.

Frame casting . . .
of machine is 15 ft long, 6½ ft high, 6 ft wide, and weighs about 65,000 lb. Die platens are 72 x 55 in. and hold dies up to 50 in. high. The locking mechanism adjusts for die openings from 10¼ to 36 in. Large-dia screw behind movable die platen is motor-driven for fast, accurate adjustment of die height. Plunger prefill stroke is 25 in. and max shot pressure is 20,300 psig. Machine also has a prefill injection system, shot position adjustment from 4 to 14 in. below centerline, an automatic grease lubricating system, and automatic hydraulic ejection. Rated 1200-ton capacity was attained at 60% of max pump pressure.

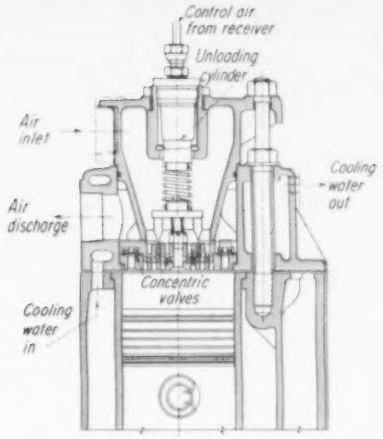




Modified Engine Compresses Air

Replacing one cylinder head of a 2-cyl. diesel with a head containing concentric plate valves lets it serve as a compact engine-compressor.

Called Dies-l-air, the power unit was designed by Nordberg Mfg. Co., Milwaukee, for Automatic Power, Inc., Houston, Tex. It powers foghorns installed on offshore navigation hazards.



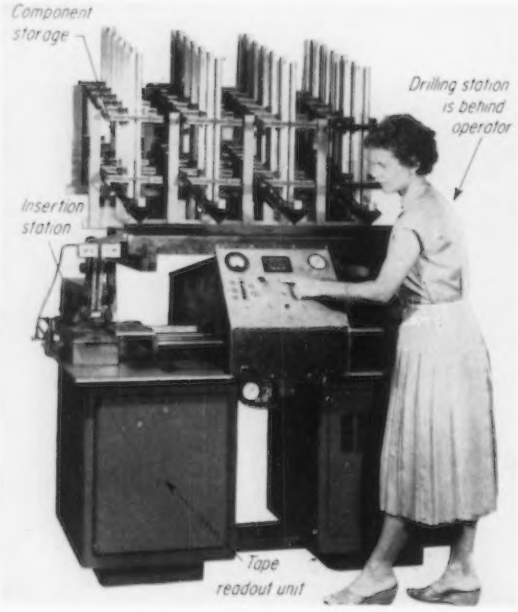
Compressor head . . .
contains concentric suction and discharge valves that give low clearance volume, an unloading valve and a water jacket for cooling incoming air. Valve is designed for disassembly without disturbing cooling water or air discharge connections. Compressor handles 30 cfm at 60 psig or 26 cfm at 100 psig. Engine is governed at 800 rpm.

Works Like an Elephant

But instead of only two lifting tusks and a trunk, there are two pairs of tusks that pick up the log. An electrically powered joint gives upper tusks their gripping action.

This off-the-road fork lift truck was designed by R. G. Le Tourneau, Inc., Longview, Tex., for handling redwood logs at a California sawmill. The machine handles 22-ton loads.

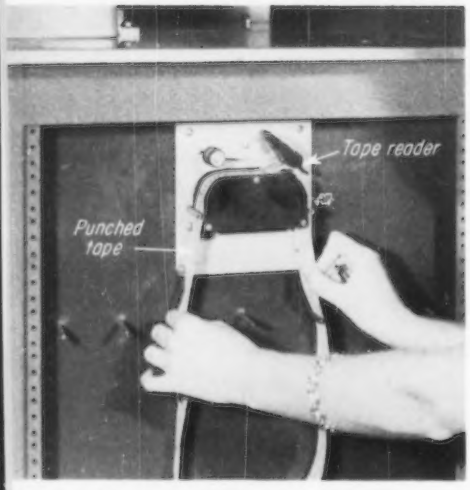
High-starting-torque motors . . .
drive each of the 4 wheels, the steering gear, the lifting and tilting mechanisms and the two joints of the tusks. A diesel-driven main generator supplies power for the motors; no clutches or mechanical drives are used. Centralized power generation, with individual electric drives spotted wherever torque is required, makes machine adaptable for use with attachments that have no mechanical connection to engine.



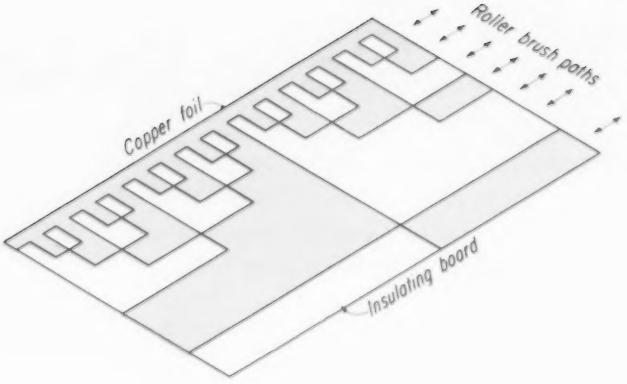
Controlled by punched tape, a two-coordinate system automatically positions circuit boards beneath a drilling and a component-inserting head. A preset pattern is followed as holes are drilled in one board while components of preselected value are inserted in board drilled during previous cycle.

Called Auto-Board, the machine was designed by the Electro-Machinery Div. of Design Tool Corp., New York City.

Tape Programs Assembly



Storage chutes . . .
feed as many as 24 different components to a conveyor belt that takes them to the insertion head. Here leads are cut to size and formed, then component is inserted into a board according to instructions programmed by the punched tape. Pushbuttons enable operator to select one of three functions—drill, drill and insert, or insert—before pushing button that starts automatic cycle. Other buttons provide manual positioning and testing. Operator loads machine by hand after each cycle. Machine is programmed by a combination of electrical, hydraulic and pneumatic devices. Relay circuits are the memory that holds drilling and component-selection data while tables move.



Linear digital readout panels . . .
provide 10 discrete positions per in. for boards up to 10 x 12 in., or 12,000 possible hole locations. Digital code is an etched copper-foil pattern on phenolic insulating board. A separate panel is used to position tables along each coordinate axis, but motions occur simultaneously. Holes punched in tape establish parallel electrical paths through readout panels, and relay contacts to the solenoid valves that control table motion. Ball-contact brushes ride the readout panels, making circuits as they contact foil. Table moves to the one position where all established circuits are open.

1 Milling machine . . . with rotary table is one of the more common of the 31 cam-manufacturing methods discussed here. Either increment or tracer-control cutting can be employed. For increment method, machinist uses table of polar-cam dimensions at angular increments. Cam goes on rotary table or dividing head and a scallop or flat cut is taken at first position. Then cam is indexed to new angular position, table is relocated to new radial dimension and second cut is taken on profile. Cuts produce a series of scallops; accuracy depends on their size. Often, work is finished by hand-filing the scallops.

With tracer-control cutting, profile is scribed on work and a rough cut is taken. Work is then clamped to a hardened master cam and operator skillfully maintains milling cutter in contact with master to cut profile.

WHICH WAY TO MAKE A CAM?

HAROLD A. ROTHBART

Associate Professor of Mechanical Engineering
City College of New York

MEET THE AUTHOR:

Prof. Rothbart is known for his reference book, Cams—Design, Dynamics, and Accuracy, published by John Wiley & Sons. Illustrating hundreds of cam profiles and arrangements, the volume also analyzes stresses and serves as a guide to materials. Expanding on the text of his book, the author has here compiled, for the first time, a complete list of cam-manufacturing methods, along with the probable accuracy that can be obtained from each.

There are many ways to manufacture a cam. The choice depends on type of cam, accuracy, and production quantity desired. But the choice can be boiled down to three classes of equipment—standard machine tools, those with special cam-milling attachments, and specially designed machines. Each class can use one or more of three methods for actually cutting the cam:

Layout—the desired contour is laid out on the cam blank, then the machine operator cuts the blank along the scribed line.

Increment—a series of scallops or flat cuts are made tangent to the cam profile, after which ridges are removed by hand operations or by grinding.

Tracer control—the cam surface is milled or ground by a cutter guided by an information device such as a hardened master cam, punched tape, or servo system.

Gathered together here is a complete list of cam-manufacuring methods, along with the probable accuracies that each type of machine will give. Eleven of the more popular methods are illustrated and described in greater detail.

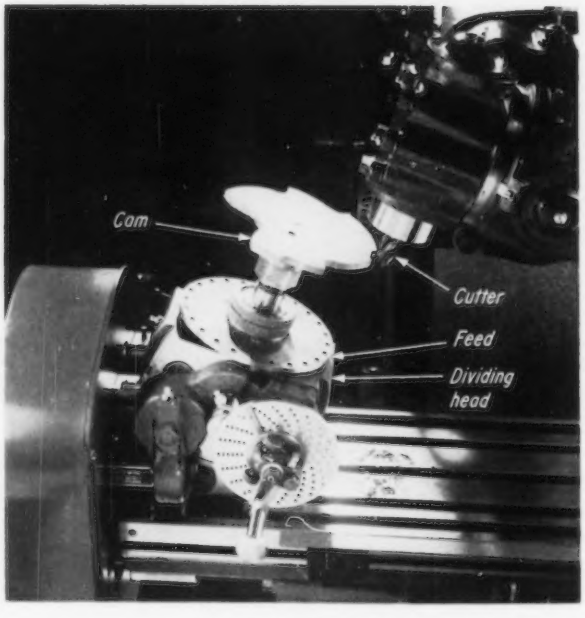
(continued on next page)

TO MAKE A CAM

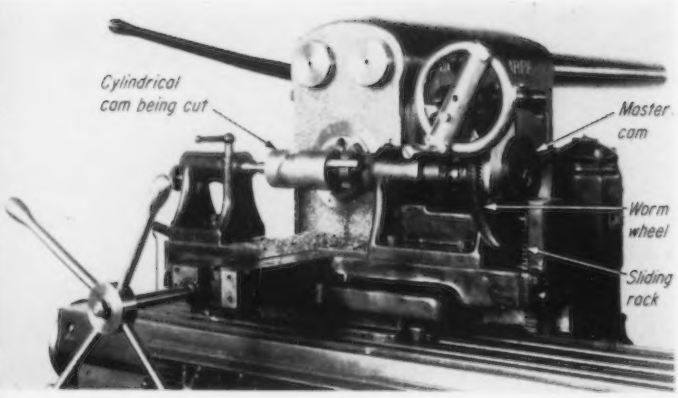
CAM MANUFACTURING METHODS

Machine	Fig. No.	Type of Cam	Method of Cutting	Comments	Probable Accuracy, in.
Contour sawing or grinding	——	Radial surface	Layout	Use only where accuracy not important	0.005 to 0.020
Milling machine and dividing head	1	Radial, groove or cylindrical	Increment, from a table of values	Slow but often employed for master cams	0.001 to 0.005
Vertical miller, or horizontal miller with vertical attachment and rotary table	——	Radical, groove or cylindrical	Layout & tracer control	Slow but often employed for master cams	0.005 to 0.010
			Increment, from a table of values		0.001 to 0.005
Universal miller with vertical attachment and rotary or dividing head	2	Radial or groove with uniform rise	Synchronous feed. Dividing head geared to table	Used for screw-machine cams	0.001 to 0.003
Milling machine with cam attachment	3	Radial, groove or cylindrical	Tracer control from master cam	Brown and Sharpe, and Kearney & Trecker attachments.	0.001 to 0.003
Profile miller or die sinking machine	4	Any cam shape	Tracer control from templet		
Cam cutter, by Rowbottom Machine Co., Waterbury, Conn.	——	Radial, groove or cylindrical	Tracer control from templet	Commercial cam machines for complex shapes	
"Keller," Pratt and Whitney, Hartford, Conn.					
"Kopp," F. Kopp Machine Tool Co., Neunimdonau, Germany	——	Radial, groove or cylindrical	Tracer control using hydraulic feed	Maintains constant peripherical cutting speed for max production	0.001 to 0.003
"Sig," Morey Machinery Co., New York City	——			Has both milling and grinding attachments	
"Electronic Tracer," Pratt & Whitney, West Hartford, Conn.	5	Radial, groove or cylindrical	Tracer control using electric conductive line	Has both milling and grinding attachments	0.001 to 0.006
Cam attachment, Federa. Products, Inc., Providence, R.I.	——	Cylindrical	Increment	Uses standard horizontal miller	0.001 to 0.003
Attachment, "Helix Master," Sheffer Collet Co., Traverse City, Mich.	——	Radial or groove, with uniform rise	Synchronous feed, needs no templet	One of several cam attachments on the market	0.001 to 0.003

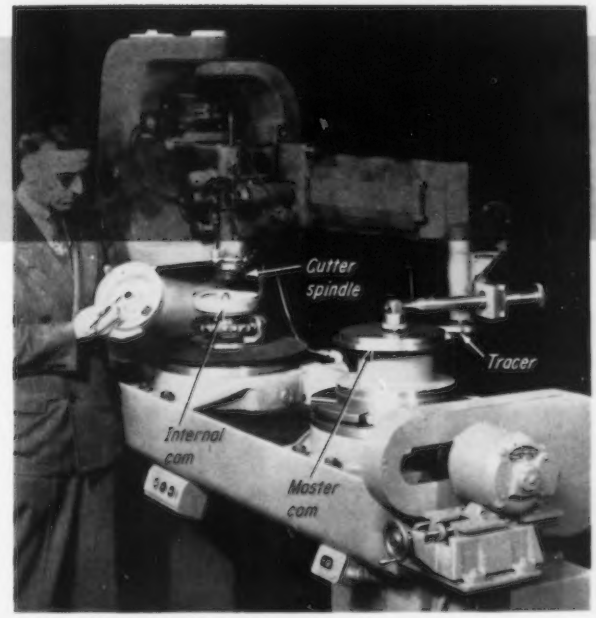
(table continued on page 70)



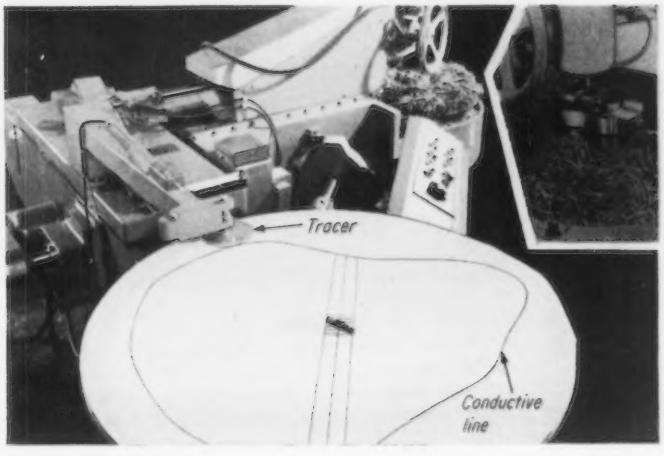
2 Universal milling machine . . . has vertical milling attachment and dividing head, synchronizes feed with rotation of cam. Position of rotating cutter doesn't move. Rotation of dividing head (and cam) is geared to lead screw of horizontal table. Synchronizing cam rotation with horizontal feed produces spiral curve that gives constant-velocity rise. Max rise is had when cutter and cam axis are in vertical position. Adjusting inclination of cam and cutter gives other spiral rates, ranging from zero to max.



3 Cam attachment . . .
on milling machine uses tracer-control method to cut radial, groove or cylindrical cam. Machine table remains clamped in one position during cutting. All rotative and longitudinal movements are controlled by cam attachment. Master cam is secured to worm-wheel and actuates sliding rack to control longitudinal motion. Rotary feed is at constant rate.



4 Profile miller . . .
has two spindles. One carries tracer point that contacts master cam; other carries end mill that cuts required cam. Tracer is automatic or hand operated. When automatic, a high-voltage low-current spark senses changes in gap between tracer point and master cam—without actual contact. Anticipation circuits measure extremely small gap variations and actuate servo-motors to follow the contour.

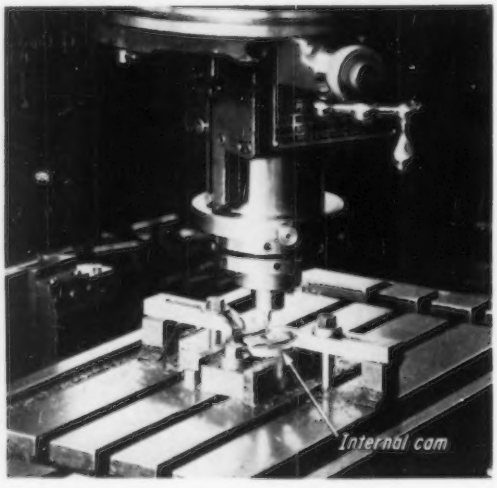


5 Cam miller . . .
has electronic control system that follows shape of electrically conductive line drawn on an enlarged master templet. System utilizes low-current spark to keep constant gap between tracer and line. Machine has both milling and grinding cutting heads, was originally developed by Pratt and Whitney Corp. to machine cross-sectional contours of turbo-jet blades, buckets and vanes.

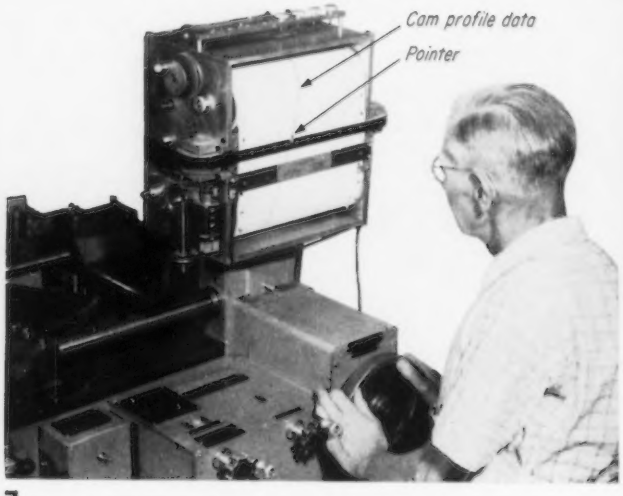
(methods continued on next page)

CAM MANUFACTURING METHODS (continued)

Machine	Fig. No.	Type of Cam	Method of Cutting	Comments	Probable Accuracy, in.
"Milwaukee Rotary Miller," Kearney & Trecker	6	Radial or groove of arc-tangent shape	Needs no templet	Resembles vertical miller but has rotary head	0.001 to 0.003
Special machine, Ford Instrument Co., Long Island City, N. Y.	7 8	Radial or groove with uniform rise. Usually for master cams	Uses paper roll for data	Method may be applied to other cams and machines	0.001 to 0.002
Special machine, Ford Instrument Co.	9	Three-dimensional	Master has increment cuts; cam cut on profiler	Slow operation	0.0005
Vertical shaper	— —	Radial, internal and external. Hour-glass shapes	Layout or increment	For large production	0.001 to 0.003
Jig borer, Moore Special Tool Co.	——	Radial	Increment	For master cams	0.0001 to 0.0003
Cam grinder, or grinding attachment	10	Radial	Tracer control	For master cams	0.0002 to 0.001
Pantograph profile grinder, Cosa Corp.,	——	Radial	Tracer control	Slow, for small cams only	0.0002 to 0.001
International Business Machine Corp.	11	All types	Digital information input	Uses vertical miller with rotary table	0.001 to 0.003
EMI Engineering Development, England; and Cincinnati Milling Machine Co.	——	All types	Digital information input	Interpolator gives smooth curve through points	0.001 to 0.003
Turchan Follower Machine Co., Detroit	——	All types	Electro- hydraulic servo control system		0.001 to 0.003
Mass. Institute of Tech., Cambridge, Mass.	——	All types	Optics applied to electronics	Excellent, but not commercially available	0.00005 to 0.001
Bendix Aviation Corp., Detroit	——	Similar to I.B.M. product	Automatic cam generation		0.001 to 0.003
Flame Cutting	——	Radial	Tracer control	Poor accuracy	0.005 to 0.020
Casting	——	All types	Precision castings	High production of small cams	0.001 to 0.020
Die Forging	——	For automobile crankshafts	Forging		0.005 to 0.020
Stamping	——	Radial	Blanking, trimming, shaving	Small thin cams	0.001
Powder Metallurgy	——	Any shape	Sintered cams	Small cams	0.001



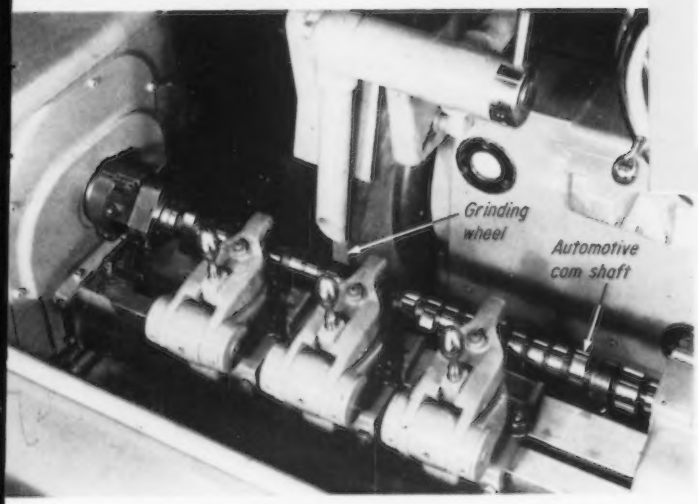
6 Rotary-head miller . . . needs no templet or dividing head, cuts circular arc or straight-line cam curves. Cross-slide shifts spindle to obtain offset. Offset of 4 in. will cut 8-in.-dia circle. Complex cam shapes are milled by series of arcs, all tangent to desired shape.



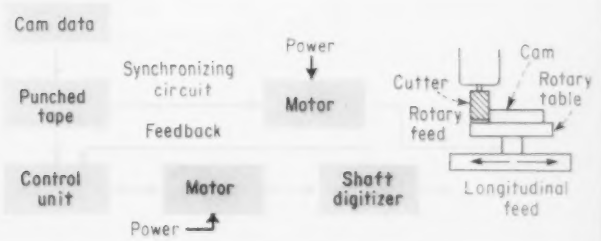
7 Data for complex cam . . . are plotted on 325-ft-long paper roll loaded into special cam cutter developed by Ford Instrument Co. Operator keeps pointer zeroed on curve. Shifting pointer controls movement of cutting head at ratio of 500:1. Large ratio is used when cutting master cams.

8 Tracing machine . . .
uses spiral-groove master cam previously machined on cam cutter shown in preceding photo. Master cam clamped on large table revolves several times for each revolution of production cam mounted on small table. This reduces the effect of errors in master cam.

9 Three-dimensional cams . . .
are fabricated on special pantograph machine. Master cam was previously cut on a jig borer to a larger scale. Production cam is first rough-machined on profiler and then mounted on shaft geared to master-cam shaft. Pivot arm holds a spherical follower that rides on master cam, and a spherical carbide burr to finish-cut the production cam.



10 Cam grinder . . .
works along automotive cam shaft, duplicating contour of master cam (not shown). Latter revolves against a roller, causing grinding-wheel spindle to move in or away from cam being ground.



11 Automatic cam manufacture . . .
has computer feeding data to servomechanism which accurately positions a continuously moving cutter. One motor rotates cam, the second operates longitudinal feed. Feedback circuit checks output shaft position and corrects for deviations from theoretical profile. Basic information is supplied to calculating machine on a punched tape. Advantages are high production, accurate profiles an all-automatic operation. Limitations: initial cost; complexity of information into computer.

REPRINT of this article can be obtained for your reference file by checking No. E10 on one of the Reader Service cards bound in this issue. For other reprints available, see "Current Reprints" listing in this issue on page 127.

Small Induction Motors *are* GOING PLACES

Design is putting them into the busy world of business machines. The authors tell why these motors, now greatly improved, are taking work away from the speed-regulated, series-wound ac and universal types that ruled the field so long.

I. E. ROSS, *Manager, Engineering*
R. W. GROOT, *Product Planner*
Specialty Motor Dept.
General Electric

Ever since the keys of a Woodstock typewriter were motorized, in 1926, a revolution in business machines has been taking place. It now includes the trend to the single-phase induction motor. Already this small but busy newcomer to the business world has taken over the powering of typewriters and voice recorders. And you can expect, within the next few years, to see these motors running most accounting machine calculators, adding machines, visual-aid movie projectors, cash registers and check writers.

The induction motors can not only supplant most existing series-wound small motors, but often replace them. This is because they can be made to match size, shape, cost and horsepower. Square shapes are available too, with resulting size reductions.

Reason for the switch-over from series-wound is: the latter have finished their job. Their designs catered to differences in American and foreign markets, where dc and odd-cycle ac current demanded series-wound, universal (ac-dc) motors. These had good starting characteristics, adjustable speed, high maximum speed, low weight per hp. But they had disadvantages too.

For example, speed governors were essential to limit no-load speed. They were usually off-on contactors actuated by centrifugal-speed mechanisms, and needed resistors and capacitors to filter the electrical noise. These contacts plus the motor commutators were sources of wear, heat and noise, and for long life it was desirable to run the motors only when necessary.

Of course, many applications were (and still are) ideal for series-wound ac and dc motors: Portable tools have taken advantage of the high hp per lb; small blowers have demanded very high speeds; variable speeds still call for speed-governed series motors; universal operation (although fast disappearing in this country) still requires series windings.

INDUCTION MOTORS ARE SIMPLER

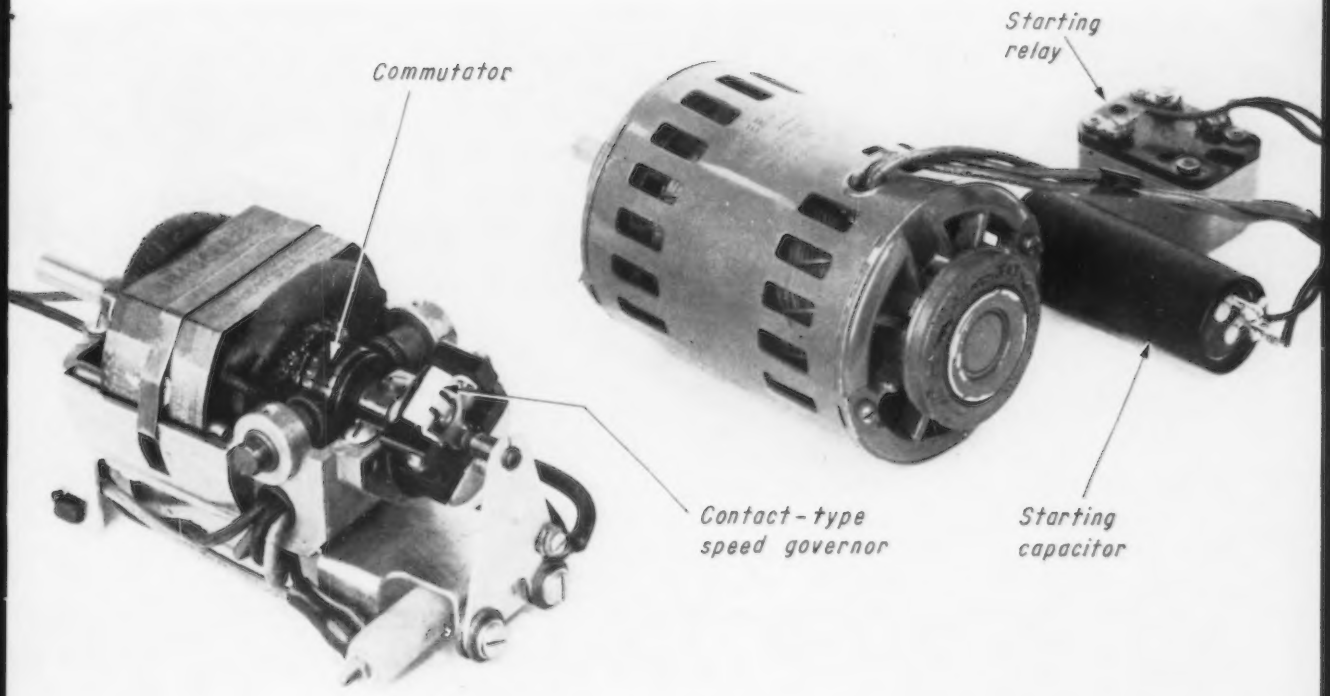
World War II encouraged development of special 400-cycle induction motors that were very compact, and continuation of this trend has resulted in 60-cycle commercial models ranging from 1/100 to 1/12 hp. Commutators and speed governors are gone, and so are their problems. Casings are shell-type (cylindrical from one end to the other, with flat end covers), or conventional (rounded end-bells). Squirrel-cage-type rotors are used, and can be constructed with end rings and bars cast of aluminum; slotted-iron cores hold the cast aluminum and provide magnetic paths. The current flows where it should—in the aluminum—because the iron, even though in intimate contact, has a relatively high electrical resistance. Stator windings are kept cool by numerous strategic ventilating openings in the shell and end covers, plus integral fans at each end of the rotors. Air flow at each end comes into the motor axially and leaves radially.

DEPENDABLE START-STOP OPERATION

Small induction motors with starting windings have start-stop capabilities fully as good as those of the speed-regulated series-wound type. Life-wise they are far better. Induction motors of proper design can be started 25 times a minute and can withstand 10 to 15 million operations. An external starter such as an accelerating-current relay can serve to initially energize the starting windings, then automatically switch to the running windings when the motor increases in speed. These relays are triggered by measurable decreases in winding current; the circuits include capacitors. It is estimated that induction motors with capacitors and accelerating-current starters cost no more than equivalent series motors with speed governors plus required "filtering" capacitors and resistors.

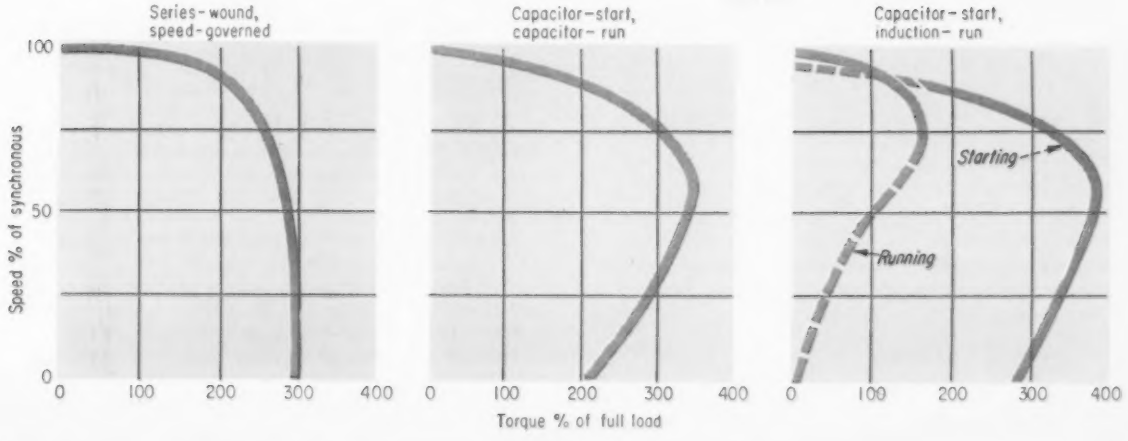
Less expensive induction motors with somewhat reduced starting and running capabilities are also available. Shaded-pole motors, for example, are low-cost, but cannot compete with series-wound motors either in starting or running performance; split-phase capacitor-start motors can.

Generally, capacitor-start induction-run motors with



Supplanting a series motor . . .
the induction motor in assembly at right was designed to match size and handle same job as series-wound on left—but with better performance and life.

Tough starting jobs . . .
can be handled by induction motors as well as or better than series-wound. Curves compare typical torque and speed performance.



COMPARISON—PERFORMANCE OF SERIES AND INDUCTION MOTORS

Type	Running efficiency	Starting torque vs inrush current	Starting and acceleration torque
Series-wound, speed-regulated	Fair	Good	Good
Induction			
•shaded-pole (cheapest)	Low	Poor	Poor
•resistance, split-phase	Good	Poor	Fair
•capacitor-start, capacitor-run	Fair	Fair	Fair
•capacitor-start, induction-run	Good	Good	Excellent

relays should be selected for high starting torques; and permanent-split capacitor-start-and-run for moderate torques. One way to achieve start-stop convenience without frequent starting is to run the motor continuously at no-load, and clutch it to the load when needed.

GOOD FOR CONTINUOUS DUTY, TOO

Induction motor life is measured in years. The only sliding or rolling parts are bearings, and these are usually trouble-free. One drop of oil each year is typical maintenance; some can be grease-packed for life.

Heat generation is small, but not negligible when cumulative. Operating temperatures (for long motor life and human comfort) can be kept to satisfactory levels by several techniques applicable to both series-wound and induction motors:

- "High-iron" construction (improves magnetic path in iron stator at expense of copper conductors)
- Ventilated stator end-windings (compensates for increased conductor losses by circulating cooling air against carefully designed end loops)
- Clutching of load (lets motor run at no-load except when needed)
- Improved insulation

SPEED CONTROL

An induction motor runs just below synchronous speed at no-load, and drops 2% to 5% in speed as load is added. The number of poles and the frequency determine the speed. For example: 2-pole 60/50 cps 3450/2875 rpm defines a motor which is designed for 60 cycles and 3450 rpm, but will operate satisfactorily (because of margin in design) at 50 cycles and 2875 rpm. More popular sometimes is 4-pole 60/50, 1725/1425, because it turns at a slower speed and requires smaller gear reductions. However, a 2-pole develops up to twice the power in the same space as a 4-pole motor. Interest has also been developing in 400-cycle motors; these turn up to 24,000 rpm synchronous (2-pole).

Output speed can be changed in several ways. Gearing is one, and belts another. A third (used primarily in larger motors) is to provide separate motor windings for both 2-pole and 4-pole operation (or other combinations) with controls arranged to choose one or the other.

SPECIFY THE RIGHT PERFORMANCE

The right motor can usually be obtained if the specifications are carefully written. For any motor, consider the following:

- Power supply (volts, cps)
- Speed (synchronous, approx. constant, or variable)
- Hp
- Starting torque
- Duty cycle (exactly what motor must do)
- Cost
- Life
- Mechanical strength
- Ambient temperature
- Comfort temperature
- Resistance to contaminants or dust
- Size
- Radio interference
- Standardized dimensions
- Availability
- Maintenance
- Over-voltage and under-voltage
- Line surges
- Vibration

Differences in performance between modern induction and speed-regulated series-wound motors are not too great (see torque-speed curves on preceding page). If neither type answers the purpose, this list of specifications will help pick some other type, such as hysteresis, shaded-pole, repulsion, or dc shunt. Always consult the manufacturer: He is an expert.

EDITOR'S NOTE: More performance information on fractional horsepower motors may be found in "Shaded-pole Motors," July '57, p 169; and "Fhp Motors," Mid-Oct 57, p H18.

Some tips for coupling and using fhp motors are given in: "13 Ways to Couple Fhp Motors," Sept 30, '57, p 120; "Adjustable Electronic Drive for Fhp Shunt Motors," Jan '56, p 222; and "Hydraulic Coupling for Fhp Motors," July '56, p 220.

Facts on starting and controlling induction motors are included in: "Applying Single-phase Capacitor-start Motors," Oct '56, p 196; "Controlling Temperature Rise for Induction Motor Drives," Jan '57, p 167; and "Multi-speed Motors," June '57, p 140.

CONTROLLED

ontrol by automatic or manual means

ff-the-shelf procurement

o motor burn-out through load stalling

orque-speed curves to meet any use

educed power-line capacity

verload protection to the prime mover

ess starting shock to equipment

ess system vibration

asy, smooth acceleration

ecreased motor size

Fig. 1—DRY AND FLUID COUPLING

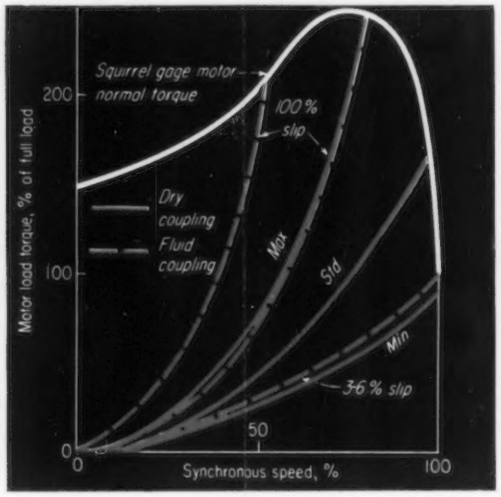
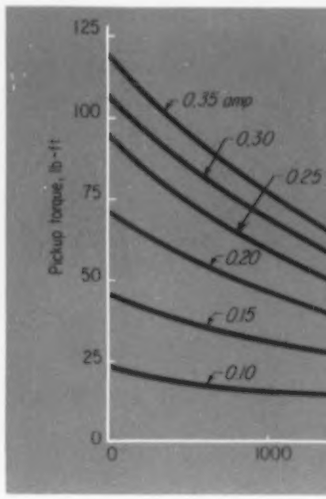


Fig. 2—MAGNETIC DISK CLUTC



ACCELERATION DEVICES

Here are seven answers when the problem is to team together a high-acceleration power source and a machine that must start at a slower rate. Each speed-buildup method described in text and basic-data chart is appraised with special advantages weighted against inherent limitations.

JOHN R. EASTMAN
Chief Engineer
Sterling Electric Motors, Inc.

Ac induction motors with low current-density windings can control machine acceleration without need for a coupling device. Motor is wound to give less torque throughout its starting and accelerating phase. This means speed remains slightly reduced at full load.

Generally, the winding is closely matched to the load and its inertia—substantially reducing initial starting shock but still delivering enough starting torque to insure equipment acceleration to running speed. Top results are obtained where torque requirements during acceleration remain essentially constant.

"Dry" fluid coupling, a recent development in the drive field, is similar to the hydraulic fluid coupling. Difference: metal shot transmits power between the rotating members.

In operation, the drive motor is connected to the housing and starts it turning at no load. The charge—metal shot—is thrown to the circumference of the housing, where it is compacted by centrifugal force and revolves with the housing. A smooth corrugated disk within the housing—the rotor—is connected to the driven machine. It is rotated by the friction and wedging action of the revolving charge. At full running speed, the coupling operates with zero slip, except under an excessive load. Torque can be varied by adjusting the amount of metal shot placed in the housing.

The couplings can have various flow-charge settings, Fig. 1. At any given setting, output torque stays constant at constant input speed, regardless of output speed. Exception: once the coupling is "locked in" for normal running at 0% slip, its torque capacity will be 30% higher than the torque when it is slipping.

Hydraulic fluid coupling is one of the first and simplest means for limiting machine acceleration under almost all conditions. The coupling has two moving parts—impeller and runner—and is driven by turbine action: difference between input and output speeds of the coupling elements. Impeller is mounted to the drive shaft and, in operation, throws a steady stream of fluid against the runner connected to the driven machine. Fluid circulation transmits power to the runner.

Power transmitted through the coupling is kinetic energy—the mass and velocity of the moving oil. Disadvantage: slippage between driver and driven machine regardless of the speed.

Hydraulic couplings are most effective at high speed; this results from increased torque when the difference in speed between coupling elements goes up. Hence, at a given motor speed, Fig. 1, torque for a coupling with 100% slip is much greater than torque at 3% to 6% relative slip. Changing the oil level will decrease the 100% slip-torque level, but if the coupling is too small, or too much oil is removed, the unit will overheat.

Units are designed for applications up to speeds of about 6000 rpm. Lower limit is about 900 rpm; below this speed the size-to-hp ratio makes fluid couplings ineffective.

Magnetic disk clutch is an electrically operated friction disk coupling actuated by direct current. A disk-shaped electromagnet is mounted to the motor shaft and energized by either 6-v or 90-v dc from collector rings and brushes, or through an air gap, depending on the model. The magnetic circuit is completed by attracting a floating armature disk connected to the driven member.

Standard units are designed for operation on 110, 220 or 440-v single phase ac. A separate control is furnished; a rectifier and rheostat to vary the applied voltage from 0 to about 90-v dc. This gives easily adjustable acceleration times and torque limit settings.

Varying the voltage permits shockless acceleration and deceleration, giving smooth buildup characteristic and time for the unit to absorb backlash and wind up from a gear train, chain or belt drive without the danger of impact loading on the machine element. Also, any desired amount of slip is possible and the clutch can be locked in for no-slip.

If the clutch is engaged under no-load, the size is based on static torque rating for which tables are available.

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CLUTCH

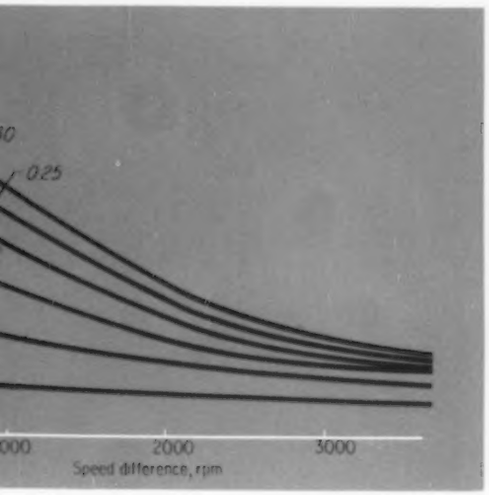


Fig. 3—MAGNETIC-PARTICLE CLUTCH

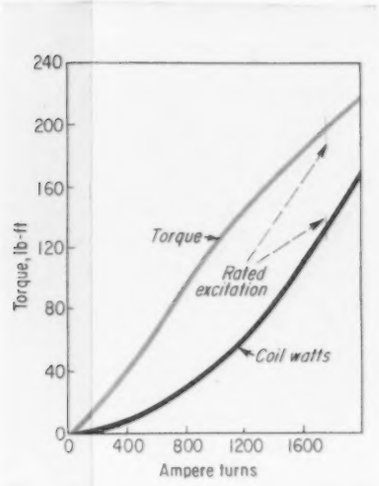
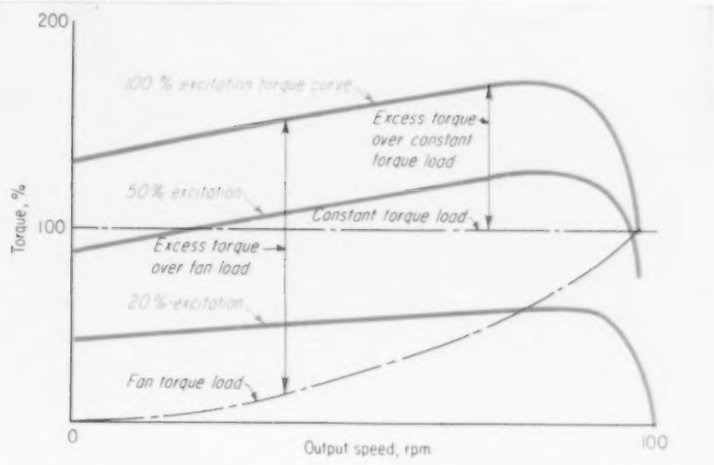


Fig. 4—EDDY-CURRENT CLUTCH



If the clutch must pick up under load, selection is on the basis of a speed-torque chart, Fig. 2. By finding the speed difference between driving and driven shaft at the instant before engagement, it is possible to determine the pickup torque of any clutch at that particular speed difference. One other factor must be considered: heat dissipation.

Magnetic-particle clutch is essentially an electrically operated dry fluid clutch. Its driving member is connected to the drive-motor shaft; it is enclosed by and rotates within, the driven member mounted on the driven machine.

Driving and driven members are independently supported by stator bearings and separated from each other by a space or gap that remains constant. Finely divided dry magnetic particles fill the gap.

Before the stator coil is energized, the particles have insignificant magnetization or bonding effect: torque transmission is essentially zero and the clutch operates at full slip during this period.

A magnetic field is produced in the gap when the stator coil is energized. Radial lines of magnetic force develop uniformly around the periphery of the driving and driven member, and create a bond.

An increase in control current increases the shear resistance and bond strength. Full excitation of the stator coil produces a particle bond capable of transmitting full torque at zero slip within the clutch rating, Fig. 3. When torque loads exceed shear resistance, the clutch slips.

Eddy-current clutch has two rotating parts within an exterior housing. One is mounted on the driving shaft; the other on the driven machine. Two end brackets complete the assembly.

The housing contains a field coil. A drum ring is mounted concentrically inside the field member and separated from it by a nominal air gap. Within the drum and concentric with it is a shaft-mounted toothed rotor. Intensity of magnetic lines of force produced in the field winding set up eddy currents near the inner drum surface opposite the rotor teeth; these currents in turn create magnetically reactive poles in the drum. This action gives torque transmission between rotor and drum.

Eddy-current units have rated torque at specified slip speeds. Also, sufficient peak torque is developed to prevent stalling caused by a momentary overload. Accelerating torque is normally in excess of the rated torque. Torque greater than rated is available from zero to maximum speed.

Factors which affect the speed-torque characteristic of an induction motor are present in eddy-current units. For example, adding resistance to the flow of eddy currents in the armature drum of the clutch is similar to adding resistance to the rotor circuit of the induction motor. Major difference: cast field poles of the eddy-current units permit infinite shape variations. Changing pole shape varies the torque-speed characteristics of the eddy-current clutch.

Typical torque curve with rated excitation and additional curves with reduced excitation are shown in Fig. 4. Excess torque—a measure of accelerating capacity—is indicated. By modulating the normal amount of excitation, any speed point within the perimeter of the curve may be continuously maintained with a tachometer-generator-governed electronic control.

Permanent-magnet eddy-current coupling is a new development resembling the eddy-current clutch. Difference: fixed excitation is supplied by Alnico magnets mounted in the coupling.

Motor shaft is connected to the copper-faced mild steel outer rotor. Output connection is to an internal die-cast rotor with integral Alnico V magnets. High eddy currents developed by relative speeds of the two rotors cause the developed torque.

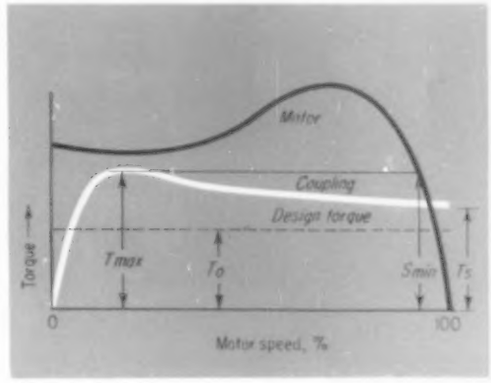
This coupling, when attached to a motor and a high inertia load, will slip during the starting period. Fig. 5 shows the output torque of a squirrel-cage induction motor plotted as a function of motor speed.

If the inertia of the load is much higher than the inertia of the motor armature and coupling, then the load and coupling are in effect at zero speed while the coupling picks up speed. The slip between the halves is essentially equal to the motor speed; the torque-slip characteristic is shown by the dotted line.

The difference between the full curve and the dotted curve is available to accelerate the driving shaft. As long as the difference does not become zero the shaft will accelerate, and because of low inertia will reach the speed determined by the intersection of the two curves. Torque, T_s, transmitted to the load is about 130% of the design torque, T_o, for the motor.

Applying T_s to the load will reduce the coupling slip and speed up the load. As the slip decreases, the torque demanded of the motor will rise and motor speed will decrease until the minimum speed S_{min} is reached corresponding to T_{max}. Further acceleration of the load and decrease in slip, eventually brings the motor and load up to the predetermined operating speed.

Fig. 5—PERMANENT-MAGNET EDDY-CURRENT COUPLING



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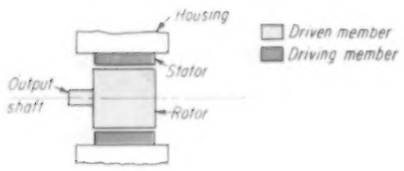
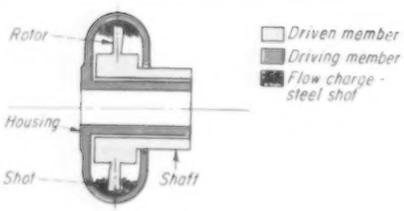
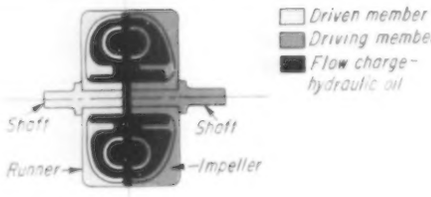
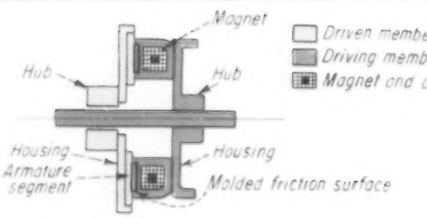
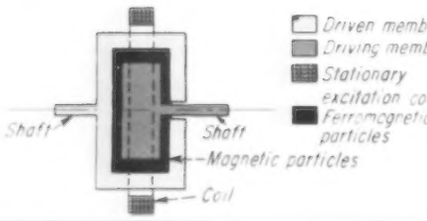
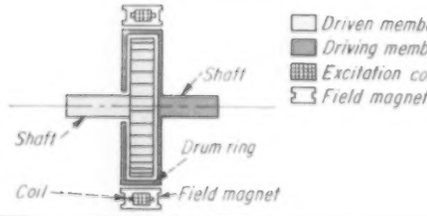
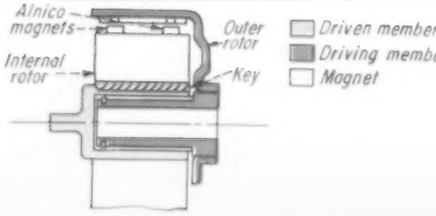
COMPARISON OF CONTROLLED ACCELERATION DEVICES (Based on units delivering 5 hp at 180

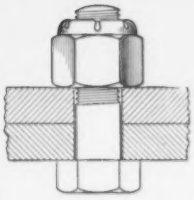
	Schematic	Approximate Initial Cost	Approximate Size for 5 hp, 1800 rpm	Maintenance Required	Auxiliary Equipment Required	Shock Load Capacity	Effects Exces Heatin
Ac induction motor with low-density winding		Same cost as standard induction motor plus about 5% for special winding.	None (motor only)	None (motor only)	None	Light to medium shocks absorbed by "cushioned" low-density winding. Heavy shocks not readily absorbed.	Damages wir
Dry fluid coupling		Next lowest in initial cost. About 60% more than driving motor alone. (Shaft mounted).	7 1/8 in. OD x 6 7/8 in. long	Change charge occasionally	Thermal safety switch, if desired	Excellent. Basically a fixed torque limiting device. Prevents transmission of transients.	Flow charge i Temperature 350 F
Hydraulic fluid coupling		Coupling costs about 50% more than the dry fluid coupling. (Shaft mounted).	9 3/4 in. OD x 4 1/2 in. long	Change fluid occasionally	None	Excellent. Fluid readily absorbs shocks and prevents transmission of transients.	Seal damag causing leak
Magnetic-disk clutch		Cost slightly more than the hydraulic fluid coupling. (Shaft mounted).	5 1/4 in. OD x 4 3/8 in. long	Replace worn disk occasionally	Control and dc power supply	Voltage can be controlled to give slippage to absorb shocks. At no slip, shock is transferred through system.	Increases dis and shorten ture life
Magnetic-particle clutch		About three times the cost of a standard induction motor. Unit foot-mounted.	8 1/2 in. OD x 10 1/2 in. long	None	Control and dc power supply	Excellent. Torque limiting device which prevents transmission of shock to the system.	Bearing fail Temperature 212 F.
Eddy-current clutch		About 2 1/2 times the cost of a magnetic-particle clutch. Unit foot-mounted.	11 5/16 in. OD x 14 3/4 in. long	None	Control and dc power supply	Excellent. Varying dc voltage will change the transmitted torque limit.	Rubbing in t air gap
Permanent-magnet eddy-current clutch		Coupling costs about 50% more than the dry fluid coupling.	10 1/4 in. OD x 7 3/4 in. long	None	None	Excellent. Essentially torque limiting.	Bearing fail Temperatur above 212

at 1800 rpm)

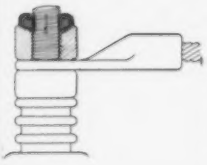
Effects of Excess Heating	Starting Characteristics	Accelerating Characteristics	Accelerating Time	Running Stability	Running Efficiency	Slip, Running Minimum	Maximum Slip Allowable	Hp Range, Available Stock	Speed Range, rpm
nages windings	Poor. Starting torque is low and a jolt occurs at motor starting.	Good. Acceleration along a smooth curve. Light inertia, rapid acceleration. High inertia, slow acceleration which may cause excessive heating.	Light to medium loads, 1–10 sec. Heavy inertia loads, 30 sec.	Fair. Variations in the load will cause considerable change in rpm	Fair. 60–80%. Low density winding gives high slip under full load running conditions.	4%	13% continuous 20% intermittent	All	600 to 3600
v charge is fused. peratures above F	Excellent. No shock is imparted to the system on starting.	Fast motor acceleration to about 2/3 full speed. Gradual load buildup over a longer period.	1 sec to 3 min	Excellent. Under rated load and speed the unit locks in with no slip.	Excellent. 100%. No slip at full load	None	5% continuous 100% intermittent	1 to 500	500 to 3600
l damage ing leakage	Excellent. No shock is imparted to the system on starting.	Motor accelerates instantly to about 2/3 speed. Load is brought up gradually over a longer period.	2 sec to 5 min	Very good. Shocks in load, however, will cause increased slipping.	Very good. 94–97%. Constant slip under full load causes heat loss.	1%	6% continuous 100% intermittent	1/2 to 500	600 to 6000
eases disk wear shortens armature life	Excellent. Some cases require auxiliary servo equipment. Permits any desired starting characteristic.	Acceleration set by dc voltage control. Basically an adjustable torque limiting device.	1 30 sec	Excellent. With full power applied, the clutch acts similar to a fixed coupling.	Excellent. 100%, if clutch is locked and driving is straight through.	None	0% continuous 100% intermittent	1/50 to 200	0 to 10,000
ring failure. peratures above F.	Excellent. Controlled by varying dc voltage applied to winding. Low voltage; slow, smooth start. High voltage; quick start.	Acceleration characteristics closely controlled by varying dc voltage applied to winding.	1 sec to 5 min	Excellent. Clutch can be locked in to give zero slip.	Excellent. 100%. Clutch is locked in.	None	10% continuous 100% intermittent	Subfractional to 250	0 to 6000
bing in the gap	Excellent. Controlled by dc voltage to winding. Low voltage; slow, smooth start. High voltage; quick start.	Closely controlled acceleration by varying dc voltage applied to winding.	2 sec to 30 min	Good. Can be varied by changing the dc excitation to the winding.	Very good. 97%. Efficiency decreases with increased slip.	5%	100% continuous 100% intermittent	1/4 to 20,000	0 to 3600
ring failure. peratures ve 212 F.	Excellent. No shock imparted to system on starting.	Fast motor acceleration to about 2/3 full speed. Gradual load buildup over a longer period.	1 sec to 10 min	Very good. Shocks in load will cause increased slippage.	Very good. 90–100%. Constant slip under full load.	1%	30% continuous 100% intermittent	1 and 2 hp (3 to 15 hp soon)	100 to 3600

Ten fastening problems solved by ELASTIC STOP® nuts

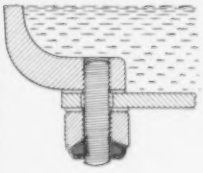
TIGHTENED AGAINST THE WORK



Vibration and impact proof bolted connections in standard applications.

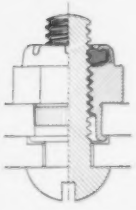


On all electrical terminals subjected to vibration in transit or operation, and for any electrical or electronic assembly where positive contact must be maintained.

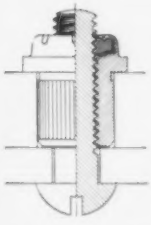


To seal bolt threads where leakage past stud threads must be prevented.

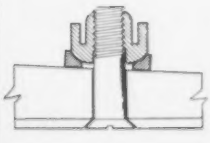
FOR MANY SPECIAL FUNCTIONS



Blind fastening applications where nut is "clinched" into sheet metal . . . becoming self-retaining as well as self-locking.

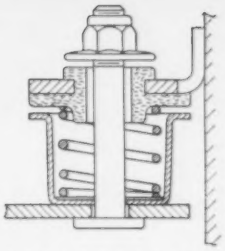


To eliminate drilling and tapping and provide steel thread strength for soft metals, an ESNA spline nut is pressed into a bored hole in casting.

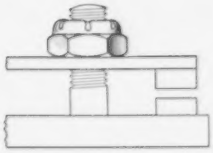


Simplified self-aligning self-locking fastener for bolting two non-parallel surfaces.

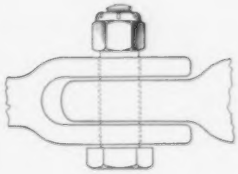
LOCKED ANYWHERE ON THE BOLT



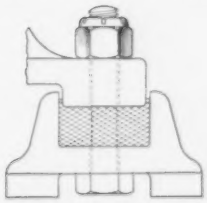
Spring-mounted connections or dynamic balancing, where nut must stay put yet be easily adjusted. (Flanged face eliminates need for extra washers.)



On make and break adjustment studs where accurate contact gaps must be maintained. Note "thin" height design for limited clearance.



For bolted connections requiring predetermined play.



For rubber-insulated and cushion mountings where the nut must not work up or down.

HOW THESE NUTS SOLVE SO MANY FASTENING PROBLEMS, ELIMINATING EXTRA PARTS AND OPERATIONS...

The red locking collar of an ELASTIC STOP® nut grips bolt threads with a perfect fit that will not loosen under severe vibration or stress reversals, and seals against liquid seepage. By bringing nut and bolt metal thread flanks into firm contact it eliminates wear producing axial play. The elastic locking action of the insert-type stop nut does not distort or gall bolt threads. It is reusable many times.

Send for the following free information: Elastic Stop nut bulletin; Rollpin® bulletin. Or enclose a drawing of your product for specific self-locking fastener recommendations.

ESNA®

ELASTIC STOP NUT CORPORATION OF AMERICA

N30-32 VAUXHALL ROAD, UNION, NEW JERSEY

Design better and cut costs with this *Fastener*

It's easy to overlook some of the many factors in joint design and fastener selection. Here's a question-and-answer review to help you cover all the points. It can also help you turn up less-expensive fastening methods.

OVER-ALL DESIGN

	YES	NO
1. Is this a product that will require disassembly? (How often?) Under what conditions (in the shop, where tools are available, or in the field?)	☐	☐
2. Do any military specifications apply to over-all design? To the fastener or fastening method itself?	☐ ☐	☐ ☐
3. Could the part be designed in one piece—perhaps taking advantage of some new production method—to eliminate fastening?	☐	☐
4. Are there likely to be problems of galvanic corrosion, between the parts, or between the parts and the fasteners?	☐	☐
5. Is there a finish on the parts that might be damaged by some joining methods?	☐	☐
6. Will the joint be subject to unusual vibration or impact conditions?	☐	☐
7. Does it have to be gas or water-tight?	☐	☐
8. Is the assembly so designed that it will be necessary to apply and lock the fastener from one side, requiring blind rivets or similar devices?	☐	☐
9. Could a pressed fit or a crimped joint do the fastening job?	☐	☐
10. Is the fastener made from suitable material? (i.e. mild steel, spring steel, stainless, nonferrous, or plastic)	☐	☐
11. Would it be possible to substitute magnetic holding or other "new" techniques for conventional methods of fastening?	☐	☐

Specific-job Questions

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FASTENING DEVICES

1. Have you considered *all* the possible fastening units—metal brads, magnets, and the like, as well as conventional systems?	☐	☐
2. Is it possible to have the fastener do double duty—perhaps serving as an electrical contact or a decorative element as well as a fastener?	☐	☐
3. Would it be possible to use fewer fasteners (and perforate the parts at fewer points) by going to higher-strength materials? (The saving might justify their extra cost.)	☐	☐
4. Would a change in part design make it possible to use standard instead of special fasteners?	☐	☐

Checklist

	YES	NO
5. Are the tolerances as loose as can be allowed?	☐	☐
6. Where stock fasteners can not be used, would it at least be possible to specify a head size and shape that would permit use of standard bar stock?	☐	☐
7. Have you considered all the possible holding methods: self-locking nuts, cotter pins, staking, adhesives, flow-on sealants?	☐	☐
8. Would it be advisable to use molded-in or cast-in inserts?	☐	☐
9. Have you considered plastic or plastic-coated fasteners to eliminate separate cushioning between fastener and part?	☐	☐
10. Is the fastening device reusable where necessary?	☐	☐
11. Does the fastener lend itself to possible mechanical assembly?	☐	☐
12. Is the fastener simple to apply? (If not, chances are a different one should be used. Consider preassembly, self-tapping etc).	☐	☐

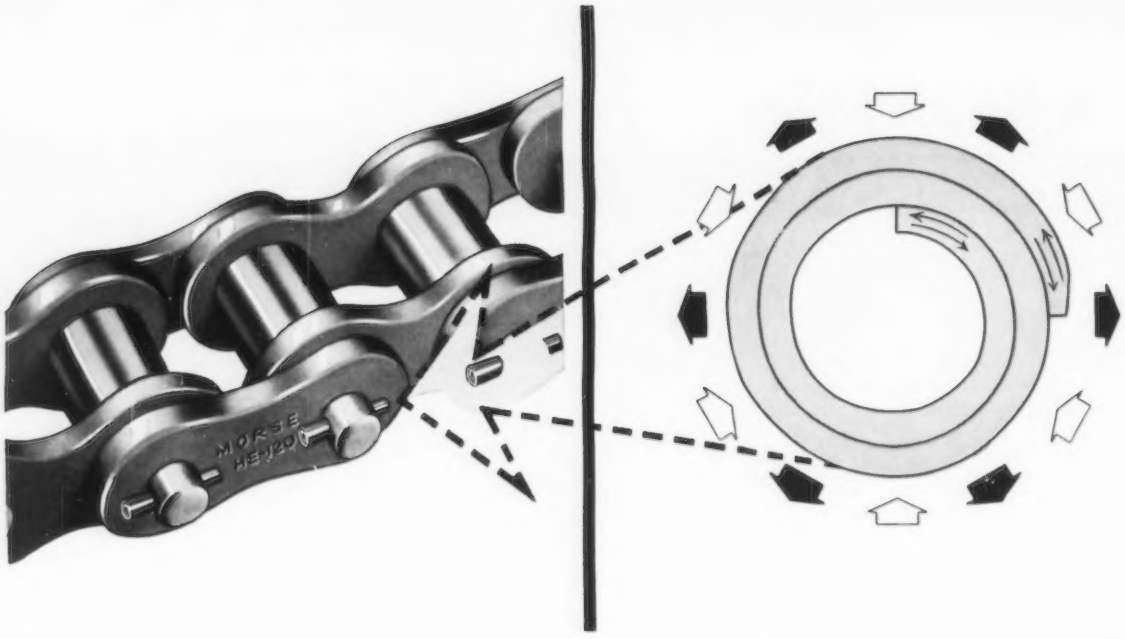
Specific-job Questions

PERMANENT JOINTS

1. Are the parts likely to be warped, or is there a finish that might be damaged, by elevated-temperature joining methods?	☐	☐
2. Have you considered such techniques as "cold" pressure welding, metal stitching, use of structural adhesives?	☐	☐
3. Is the part so designed that welding, soldering, or brazing fluxes can easily be removed?	☐	☐
4. Have you provided a sufficient radius for the filler metal?	☐	☐
5. If you are using plastics, have you considered "spin welding" (where two parts are pressed together while one is spinning, friction heats joint, melting material) or the new torch-welding techniques as well as conventional fastening and gluing methods?	☐	☐
6. Will the appearance of the joint itself be important—perhaps dictating choice of a more expensive joining technique that will provide a better-looking finish?	☐	☐

Specific-job Questions

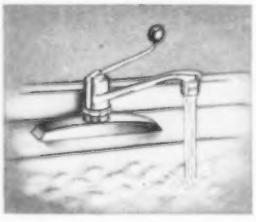
PRODUCT ENGINEERING thanks fastener companies for their co-operation, comments and help in compiling this checklist.



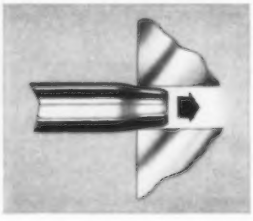
The true spring PIN has real spring *coils*

The spiral coils give SPIROL pins full spring action that is completely different from other flexible pins. Radial stress developed by compression is distributed *uniformly* throughout the spiral coils, — no critical cross-section. This characteristic enables SPIROL true spring pins to absorb high stress and shock, and withstand severe vibration. You gain the maximum benefits of cost reduction and design improvement only when you use a true spring pin with SPIROL's unique, coiled shape.

SPIROL coils offer these exclusive advantages



Non-heat-treated metals — such as low-cost brass, copper, nickel stainless steel — can be used in SPIROL true spring pins. Less resilient metals flex without failure, because there is no concentration of stress.



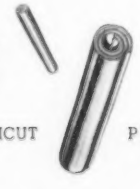
Wider hole tolerances eliminate reaming, reduce drilling rejects, cut production costs. Both plus *and* minus tolerances are allowed because of SPIROL spring pin's greater flexibility in expansion and compression.

Miniature sizes retain flexibility and strength of the spiral cross-section. SPIROL is the only spring-type pin made in miniature diameters: 1/32" — .039" — 3/64" — .052". Standard diameters up to 1/2" in stock.

Shock resistance — extremely high resistance to shock, shear, and vibration permits use of "medium duty" SPIROL pins in the majority of applications. Heavy and light duty SPIROL pins are also available in stock.

FREE! *Write for complete literature on* SPIROL *spring pins, including price list.*

® SPIROL *the true spring* PIN



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Quick check for

Writing "Instructions"

Sooner or later every engineer has to write complete technical information about some piece of equipment or process—and write it fast. Here's a "prefabricated" outline to help do the job quickly and completely.

HECTOR E. FRENCH
Chief, Engineering Publications Dept.
Sanborn Co.
Waltham, Mass.

Items listed under "Description", "Operation", "Theory" and "Maintenance" are ones that have appeared time after time, in hundreds of different technical publications written to both government and commercial specifications. Check points are in logical sequence, not importance. To use this list, just check the topics you'd like to include, add any others that are peculiar to the subject, and you'll have an outline to speed your writing.

Editor's Note

"Instructions" writing should not be confused with article and report writing, which require a much more direct style. The reader of an article is not "pre-sold" as he is when reading "instructions" for using some machine or process that he has either bought or has to use to earn his living.

But "instructions," though they permit a more standardized presentation, must still be clear and direct. Short sentences are better than long ones. Where possible, keep words short; use active voice, not passive.

Description

- –What is this information.
- –Purpose of this information.
- –How to use this information.
- –Other publications required.
- –Illustration of equipment.
- –Identify manufacturer.
- –Equipment name and number.
- –Manufacturer's guarantee.
- –Relate to other models.
- –Relate to associated equipment.
- –Modifications available.
- –If system, what are units.
- –If in larger system, explain.
- –What does equipment do?
- –What goes in?
- –What happens to it?
- –What comes out?
- –Why do it this way?
- –What is equipment used with?
- –Where, when, why is it used?
- –Who uses it?
- –Advantages of the equipment.
- –Limitations of the equipment.
- –Advertising of product(s).
- –Advertising of company.
- –Price.
- –Reordering.
- –Order, shipment, contract numbers.
- –Shipping list.
- –Shipping damage report.
- –Re-shipping requirements.
- –Accessories supplied.
- –Accessories not supplied.
- –Basic principle of operation.
- –List characteristics.
- –List controls.
- –List connectors.
- –List cables.
- –Power requirements.
- –Weight and dimensions.
- –Operating supplies required.
- –Installation requirements.
- –Operator requirements.
- –Weatherproofing.
- –Tropicalization.
- –Warnings and precautions.
- –If system: repeat for each unit.
- –Note patent numbers.
- –Give copyright date.
- –Notes on Gov't licensing.

Operation

- –Repeat from preceding as needed.
- –Write to operator's level.
- –Operator requirements.
- –Illustrations of what operator sees.
- –Identify panel controls.
- –Unpacking.
- –Installation requirements.
- –Installation procedures.
- –Intercabling drawings, tables, schematics.
- –Identify by name and number.
- –Tabulate modes of operation.
- –When are different modes used?
- –How it operates, control-wise.
- –Operational block diagrams.
- –Enough theory for operator.
- –Pre-operational adjustments.
- –Turning on the equipment.
- –Connecting: inputs, outputs, accessory equip't.
- –Standby operation.
- –Operating the equipment.
- –Emergency operation.
- –Turning off the equipment.

(Continued on page 87)

MULTI-FLEX

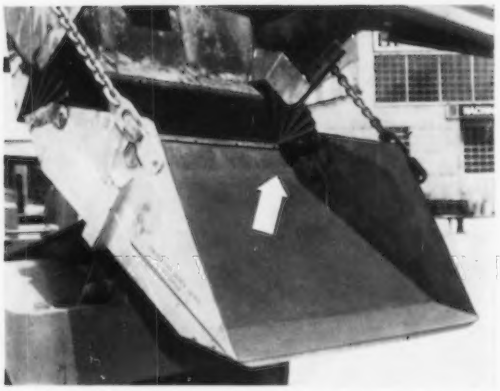
Which Multi-Flex application best solves your engineering problem ?

Here are just a few examples of the versatility that corrugated U. S. Multi-Flex® offers the equipment manufacturer.

Because Multi-Flex is specially engineered of rubber and fabric—*and not molded*—it has a built-in ruggedness that provides compression or extension without stretch or strain of the wall structure. It is available in a wide range of diameters and shapes, or can be engineered to your specifications. Inside diameters range from ¼" to 36", in constructions for service from minus 65 degrees to plus 500 degrees F.

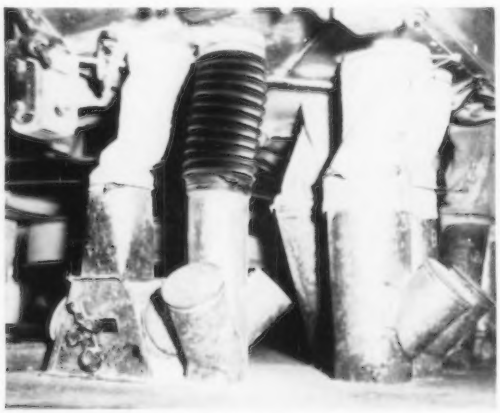
Get in touch with your "U.S." Distributor, any of the "U.S." Branch Offices, or contact us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

U. S. Multi-Flex is available in a wide range of diameters and shapes, or can be engineered to your specifications.



On this Dempster-Dumpster, Multi-Flex flat pleated sheet—acting as an accordion closure sealing an arc—combines a rubber-and-fabric strength to resist gouging and abrasion.

Multi-Flex connectors are used on this vacuum filter, taking care of axial movement and misalignment. They are especially valuable where conventional connectors will not take the required movement. Connectors can convey liquids, gases or granular solids.



In this flour sifter, Multi-Flex boots function as sifter socks conveying sifted flour to the bin. Circular motion of the sifter requires extreme extendability of the socks. Multi-Flex solves this problem and far outlasts fabric socks.

Mechanical Goods Division

United States Rubber

See things you never saw before. Visit U. S. Rubber's New Exhibit Hall, Rockefeller Center, N.Y.

Quick check for Writing "Instructions" (concluded)

–Post-operational adjustments.
–Keeping log of operation.
–Local and remote operation.
–Warnings, precautions.
–Supplies needed.
–Replacing supplies.
–Repeat above for each mode.
–Define unusual expressions.
–Explain unusual procedures.
–Refer to technician's adjustments.
–Operator's tests for operation.
–Operator's maintenance check chart.
–Fuse, tube, vibrator, crystal, indicator and plug-in-unit replacement table.

Theory

–Repeat from preceding as needed.
–Write to reader's level.
–How it works, not why.
–What goes in?
–What happens to it?
–What comes out?
–Compare with familiar equipment.
–Differences between models.
–Diagrams: systems block, unit block, vector, simplified schematic, complete schematic, primary power dist.
–Oscilloscope wave patterns.
–Wave-shape comparison chart.
–Signal-flow analysis.
–System-operation theory.
–Unit-by-unit theory.
–Stage-by-stage theory.
–Theory: by functions performed.
–Theory: output toward input.
–Theory: input toward output.
–Math. basis of operation.
–Theory: each mode of operation.

Preventive Maintenance

–Repeat from preceding as needed.
–Write to technician's level.
–Technician requirements.
–Check-chart for proper operation.
–Maintenance check-chart.
–Lubrication chart.
–Hydraulic maintenance chart.
–Periodical checks (hourly, daily, etc. through annual)
–How gain access for maintenance.
–Periodic overhaul procedures.
–Precautions, warnings.
–Special test circuits.
–Special test setups.
–Re-tropicalization.
–Re-weatherproofing.
–Specify lubricants.
–List special tools.
–List special equip't.
–Tube, fuse, vibrator, indicator, crystal and plug-in-unit locations.
–Pre-maintenance procedures.
–Post-maintenance procedures.
–Cleaning, painting, polishing.
–Corrosion, rust, water, salt-spray, damage, air-filter, cable, connector check.
–Parts-replacement schedule.
–Where to buy replacements parts.
–Supply replacement schedule.
–Where buy supplies.
–Safety precautions.

Corrective Maintenance

–Repeat from preceding as needed.
–Write to technician's level.
–Technician requirements.
–Recommended maintenance approach.
–Illustrations of equipment.
–Component identification charts, drawings and photos.
–Troubleshooting output to input.
–Troubleshooting input to output.
–Troubleshooting: for system, by unit, at controls, by symptoms, by test points, by test signal.
–Signal tracing chart.
–Charts: Oscilloscope wave-form, voltage, resistance.
–Diagrams: servicing block, simplified schematic, over-all schematic, unit-by-unit schematic, vector, primary power.
–Mechanical exploded views.
–Overhaul procedures.
–Mechanical disassembly dwgs.
–Mechanical reassembly dwgs.
–Accessory equipment required.
–Special tools required.
–List faults and probable causes.
–Special test circuits.
–Illustrations showing adjustments.
–Mechanical, hydraulic, pneumatic, electrical servicing.
–Disassembly, reassembly.
–Emergeney repair.
–Voltages on schematic dwgs.
–Wave-shapes on schematic dwgs.
–List of component parts.
–Parts manufacturers.
–Parts ordering.
–Repair: cabinet, corrosion, rust, water damage.

Things to Remember

–Covering letter.
–Get your company's name on it.
–Get your name on it.
–Give date, department.
–Type one side, double spaced.
–Drawings, pics better than words.
–Hold consistent nomenclature.
–Hold consistent technical level.
–Will it be understood?
–Write to reader's level.
–Write to reader's interests.
–Check security clearance.
–Table of contents.
–List of illustrations.
–List of tables.
–Number the pages.
–Use short words.
–Use simple sentences.
–Keep paragraphs brief.
–White space for easy reading.
–Step-by-step procedures best.
–File a reference copy.
–Keep a copy yourself.

Tests show the Worthington QD Junior stays tight even under a torque force of 3300 pounds.

the little

SHEAVE WITH THE BIG GRIP

The Worthington QD Junior is built for a lifetime of service. Like the famous heavy-duty QD, this two-piece, light-weight sheave has a heavyweight's grip. It's built for staying power—won't loosen or slip under shock or pulsating loads. Yet it's always easy to remove from the shaft.

1. *Improved hub design* patterned after our heavy duty QD—tapered, split. A Worthington development to grip the shaft and still provide easy assembly and removal.

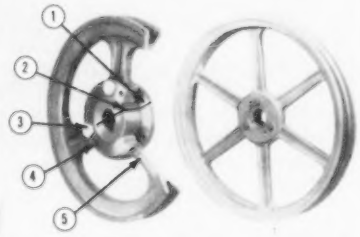
2. *One common hub* for complete range of pulleys in "A" and "B" Section, 3.2" PD through 18.4" PD in single and double groove—108 sizes in all.

3. *Simple 2-piece assembly* drawn up by three heavy hex head bolts. A standard wrench is all you need to assemble or remove.

4. *Tapped holes in sheave* for using pull-up bolts to break cone grip when removing pulley from hub.

5. *Distinctive I-beam arm* (in larger sizes) to give more strength with less weight.

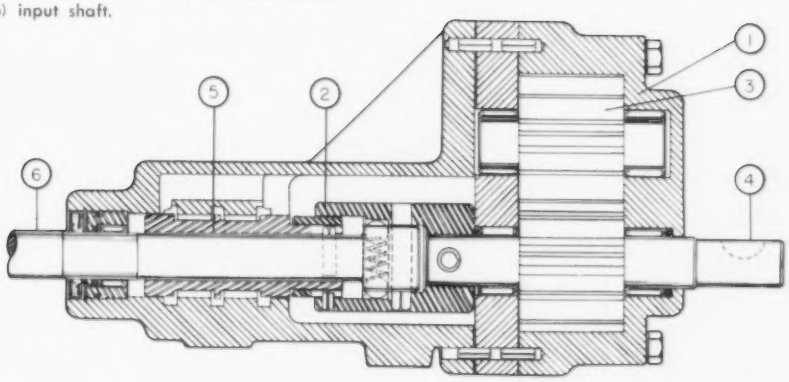
Get all the facts. Write for your free copy of descriptive bulletin FHP-100-B1. Worthington Corporation, Section 79-8, Oil City, Pa.



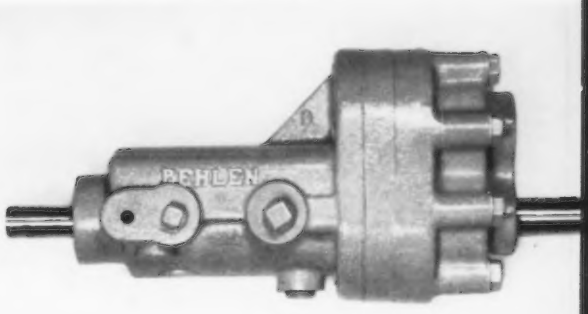
Single Groove • Two Groove

WORTHINGTON

(1) body casting; (2) cam slot and pin shifting mechanism; (3) gears; (4) output shaft; (5) controlling spool-type valve; (6) input shaft.



Mechanical Force Adjusts or Reverses Hydraulic Motor



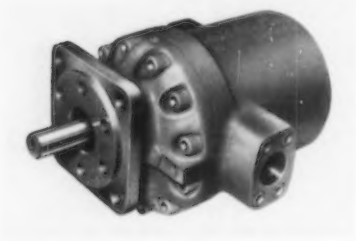
This gear motor is essentially a fluid-operated hydraulic circuit control. It can be actuated by as little as 1 lb of mechanical force. Present models were primarily designed for power steering systems in trucks, earthmoving equipment and other vehicles. When rotary force is exerted on the input shaft by driver (or when shock or other sudden loads occur), a system of slots and pins functioning like a linear cam automatically position a spool-type valve. This directs hydraulic pressure to the proper side of the gear motor at a rate proportional to compensating effort required at the output shaft. Number of turns is unlimited in either direction, even under full power.

Zero pressure prevails in this system except when gear motor is operating. Maximum pressure is determined by setting of safety valve on pump or other hydraulic-pressure source. A pump designed for use with this gear motor is available from the manufacturer. Motor may be mounted in any position; both right and left-hand rotation is possible.

Pressure required is 800 psi (2.1 hp); volume required, 4.5 gpm. Output speed is 60 rpm; output torque, 650 in.-lb. Dimensions, 15⅛ x 4¾ x 6⅝ in. Prices range from $58 to $70, depending on quantity. Standard units are available from stock. **Behlen Mfg. Co., Inc., Columbus, Neb.**

Circle 1, inside back cover

CONTINUED ON PAGE 90



Hydraulic pump-motor . . .

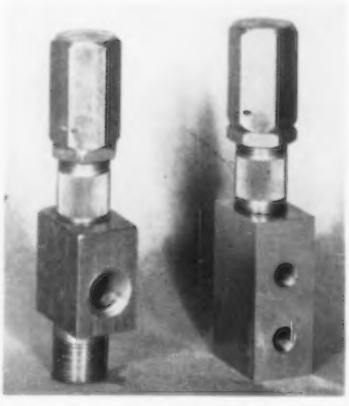
designed for 2000-3000 psi service, may be flanged or foot-mounted. When used as pumps they are for continuous operating pressures of 2000 psi, with surge pressures to 3000 psi. Pumps are available in capacities from 7.5 to 12 gpm at rated speed of 1200 rpm. The same units are used as motors, providing maximum torque at stall and constant torque output with a flat characteristic curve from 0 to maximum designed speed. Instantly reversible, the motors will carry overhung chain or belt loads. High torque at slow speeds are said to permit direct connection without gear or belt reductions. Limited number of prototypes for testing now available from **Berry Hydraulics Div., Oliver Tyrone Corp., Oliver Building, Pittsburgh 22, Pa.**

Circle 2, inside back cover

Flow-control valve . . .

for hydraulic use to 2000 psi, is said to be unaffected by changes in temperatures and viscosity, because of a metering orifice design. Provided with multiple ranges that permit shift from one range to another with safety for operator. Reverse free flow is obtained through a built-in check valve for bypassing flow control elements and is available in all three sizes, $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{3}{4}$ in. Standard models have two or three ports. Two-port valve directs fluid to a secondary circuit at a constant rate regardless of system pressure changes. Three-port unit divides flow from a pump into two paths, one of which is controlled flow to work at a constant rate, the other is discharged to tank. Min and max flow-control range varies with each standard valve size. Valve of $\frac{1}{4}$-in. port size has a 5-cu-in. to 5-gpm range; $\frac{3}{8}$-in. valve has a 2.75-cu-in. to 14-gpm range; and $\frac{3}{4}$-in.-port-size valve has a 5 to 28-gpm range. **Denison Eng. Div., American Brake Shoe Co., Columbus, Ohio.**

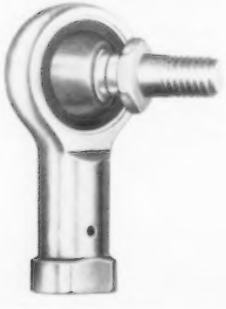
Circle 3, inside back cover



High-pressure relief valve . . .

for use in hydraulic service permits pressure adjustment to 10,000 psi setting. Available in a wide range of materials, including carbon steel and stainless steel. All can be made with high-pressure instrument threads. Inner valve parts are replaceable without tools. Other models are available for dead-tight dry-gas service and for oil-field equipment handling fluids and natural gas. **Fluid Mechanics Co., P. O. Box 194, Bellaire, Tex.**

Circle 4, inside back cover



Rod-end bearing with stud . . .

built-in may be misaligned to 35° in any direction. It can swivel at max misalignment for a full 360°, making it suitable for misaligned linkage or control rod. Construction applies load directly to center of ball and distributes it over full race curvature. Unit requires no lubrication—ball is oil-impregnated sintered bronze. Spherical race is high-tensile steel, heat treated, precision ground and black-oxidized. Outer member can be machined steel, cadmium plated, aluminum-alloy casting or malleable-iron casting, cadmium plated. Stud is cold rolled steel, cadmium plated. Rod ends are available in four stock sizes, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$ and $\frac{1}{2}$ in., male and female types. Stud lengths are $1\frac{1}{32}$, $1\frac{7}{32}$, $1\frac{13}{16}$ and 2 in. from center of ball. **Carter Engineering Co., Ferrysburg, Mich.**

Circle 5, inside back cover

High-temperature laminates . . .

and molded parts retain mechanical strength after exposure to operating temperatures up to 350 F. The heat and flame-resistant laminates are made from extra-long-staple, nonferrous asbestos fiber impregnated with a heat-resistant phenolic resin or varnish. Can be fabricated or machined by standard or conventional methods. These laminates resist water absorption through 2 hr immersion in boiling water or 30 days in water at room conditions. **Continental-Diamond Fibre Co., Newark 107, Del.**

Circe 6, inside back cover

Belt for variable speed unit . . .

can be adjusted to any desired length and is said to minimize vibration. It can be installed without dismantling machinery. Made of oil and heat-resistant neoprene, the belt is designed in a series of links held securely by patented fasteners. Comes in a range of sizes, priced competitively with the current market. **Manheim Mfg. & Belting Co., Manheim, Penna.**

Circle 7, inside back cover

Rectangular rubber seals . . .

produced by a precision fabricating technique are interchangeable with O-rings, using the same groove and require no special tooling. On static applications they are said to provide a high-performance seal. Seals can be fabricated from standard or specially developed compounds of

CONTINUED ON PAGE 92

CUT

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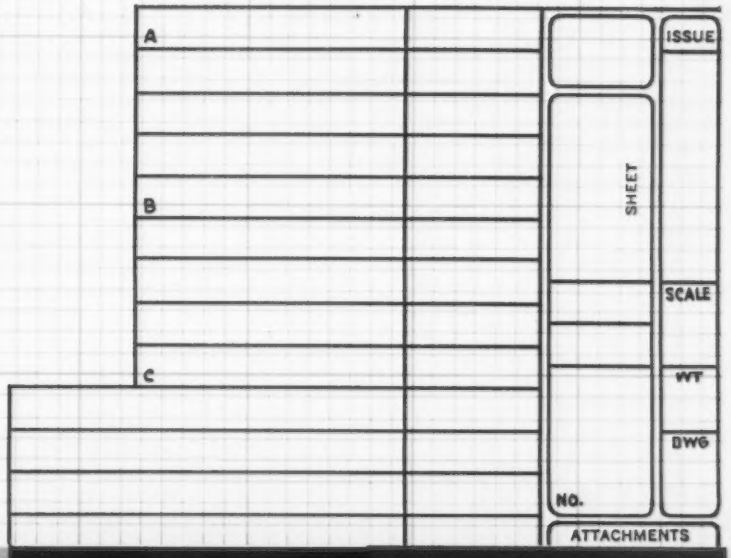

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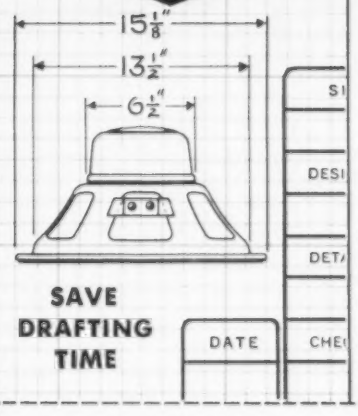

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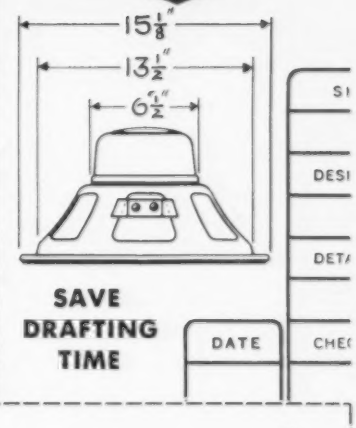

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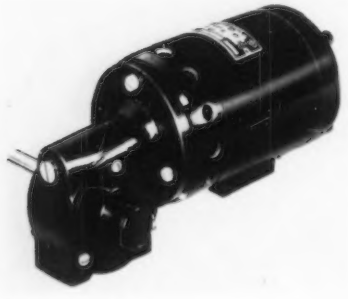
natural, synthetic and silicone rubbers to fill requirements for resistance to temperature extremes, acid and oil, low compression set and other properties. The rectangular section rings fall within the close tolerances set up for standard O-rings. **Goshen Rubber Co., Inc., Goshen, Ind.**

Circle 8, inside back cover

Adjustable cam assembly . . .

is designed for servomechanisms where it can actuate switches and similar devices at predetermined angular limits. Two stainless steel cams may be rotated relative to each other to permit adjustment between rise points from 0 to 180°. A balanced clamp secures assembly to shaft, and locks cams for desired setting. Max dia is 1¼ in. and hubs are available for ¼, ⅜ and ½-in. shafts. **Sterling Precision Corp., 54-17 Lawrence St., Flushing 54, N. Y.**

Circle 9, inside back cover



Power package . . .

consists of a universal-type brush motor and a single or double-reduction-gear unit. Series-type motor, with normalized zinc or aluminum castings, is rated 1/30 to ¼ hp at full-load speeds of 3000 to 15,000 rpm and a range of 24 to 250 v, dc, 60 cps, continuous duty; 1/30 to ½ hp at the same speeds with a range of 6 to 250 v dc, cps, intermittent duty. Single-reduction-gear unit has a torque rating to 50 in.-lb. Available with bronze and bakelite gears in ratios from 10:1 to 60:1. Mounting provisions have been incorporated in the unit itself. Can be used to mount in either the 3, 6, 9, or 12 o'clock position with shaft extension out either side. For servicing, gear unit can be detached from motor by removing three external screws. Gear-housing bearings are self-lubricated by grease in gear housing. **Howard Industries, Racine, Wis.**

Circle 10, inside back cover

Fin-cooled speed reducers . . .

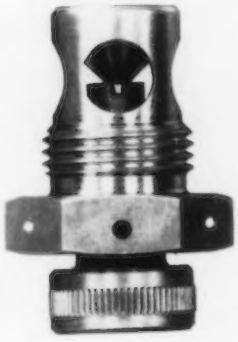
are worm-gear, right-angle-drive units. Models include horizontal and vertical output shafts. The Series 20 line of three models feature a small size-to-capacity ratio. For use with motors to 1.5 hp. Output hp and torque vary with speed and input hp. Six standard ratios for each of the three basic models range from 9:1 to 58:1. Approximate weight of each unit is 22 lb. Lubricating-oil capacity is 1 pt. Typical over-all dimensions are 7 x 4¾ x 6⅝ in. high. **Ohio Gear Co., 1400 E. 179th St., Cleveland 10.**

Circle 11, inside back cover

Flush-mounted transducers . . .

for measurement of gage, differential and absolute pressures is 0.25 x 0.47 in., and weighs 3 gm. Circuit forms a complete bridge with a nominal resistance of 200 ohm. It has an output of about 15 millivolts full-scale open circuit at 3 v excitation. Temperature limits are from —100 to 275 F. Pressure adapters are available for conversion to closed line applications. **Statham Instruments, Inc., 12401 W. Olympic Blvd., Los Angeles 64.**

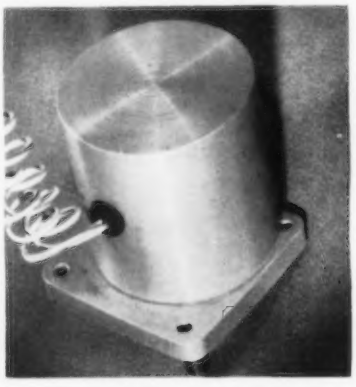
Circle 12, inside back cover



Magnetic drain plug . . .

has self-closing bayonet-type closure. A knurled circular knob, when pushed in and given a quarter-turn, instantly removes or inserts the magnetic plug. Particularly useful for cold-weather operation and engine-oil sumps, accessory drives and fluid tanks. When insert is removed, a self-closing valve immediately seals off opening, preventing loss of oil. **Technical Development Co., Glenolden, Penna.**

Circle 13, inside back cover



Miniature high-torque motor . . .

operates in temperatures of —100 to 500 F at 60 or 400 cps ac or pulsating dc. Starting torque is equal to running torque. It is basically a lightweight, ac rotary solenoid with a vibrating rate of 120 cps operated on 60 cps. This rapid vibratory motion is translated into rotary stepping motion through a fast-acting, one-way clutch. It can remain in a stalled condi-

CONTINUED ON PAGE 94

Rubber Bonded-to-Metal Parts

Precision know-how, care, and special bonding techniques assure you of parts that will reduce assembly costs, improve product operation and simplify design.

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Precision Rubber Products Corporation

"O" Ring and Dyna-seal Specialists

Dept. 3, Oakridge Drive, Dayton 7, Ohio **Canadian plant at: Ste. Thérèse de Blainville, Québec**

Corrugated roofing and siding are now readily weatherproofed during erection with Rubatex Neoprene Closure Strips

Hundreds of feet of Rubatex Neoprene Closure Strips are employed at roof, side wall, window and door junctures of Shackelford-Cox Company's combination show room and service garage at Roanoke, Virginia.

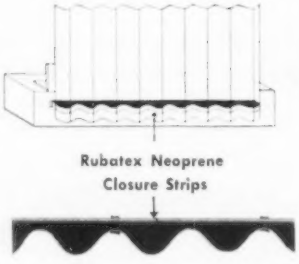
Larger structures, such as the Reynolds Metals office building in San Francisco, were weatherproofed in this fashion.

Fastened at same time as corrugated sheeting—No separate caulking operations necessary

RUBATEX CLOSED CELLULAR NEOPRENE CLOSURE STRIPS are ideally suited for corrugated metal, asbestos, glass or plastic roofing and siding installations.

Preferred by architects for the solid, continuous nature of the neoprene seal—liked by construction men because of its easy, quick installation . . . fastened at same time as corrugated sheeting . . . requiring no separate caulking operations.

RUBATEX's excellent aging and weathering properties, plus its closed cellular structure, guarantee a year-in and year-out weather barrier that's well worth your checking into.



Die-cut to fit corrugations, Rubatex forms a snug, air-, water- and dust-proof seal. It is installed on roofing under aprons of ridge roll, with flashing sections at roof junctions, side walls or end walls. Corrugated siding is sealed at foundation level and with flashing sections above and below windows and doors.

RUBATEX
NEOPRENE CLOSURE STRIPS

RUBATEX DIVISION, Dept. PD-4
GREAT AMERICAN INDUSTRIES, INC.
Bedford, Virginia

PIONEER MANUFACTURER OF CLOSED CELLULAR RUBBER

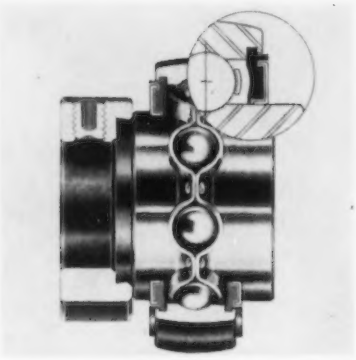
For full details and sample of Rubatex Neoprene Closure Strips—print your name in space below, attach to your company letterhead and mail to us.

Name_____

Send for Free Sample and Data Sheets

tion without damage. Suitable for remote-control switching and homing devices, rotary selector for wafer, coaxial or other types of switches, valve operation, electric counters, indexing devices, power stepping switches. **Viking Tool and Machine Corp., 20 Main St., Belleville 9, N. J.**

Circle 14, inside back cover



Prelubricated ball bearings . . .

consist of a metal flinger pressed on the ground OD of the inner ring and forming a close-running labyrinth seal with the outboard face of a synthetic-rubber element that is snapped into a groove in the bore of the outer ring. Metal flinger repels dirt and moisture and protects thin flexible lip of synthetic-rubber portion that runs on OD of inner ring, providing a positive contact seal. **Marlin-Rockwell Corp., Jamestown, N. Y.**

Circle 15, inside back cover

Air-line lubricator . . .

has transparent dome that is said to avoid oil waste. Device produces and distributes atomized oil particles. Provides constant lubrication during entire operation. The ¼-in. unit can lubricate any amount of air from ¾ to 90 cfm. Adaptable to right

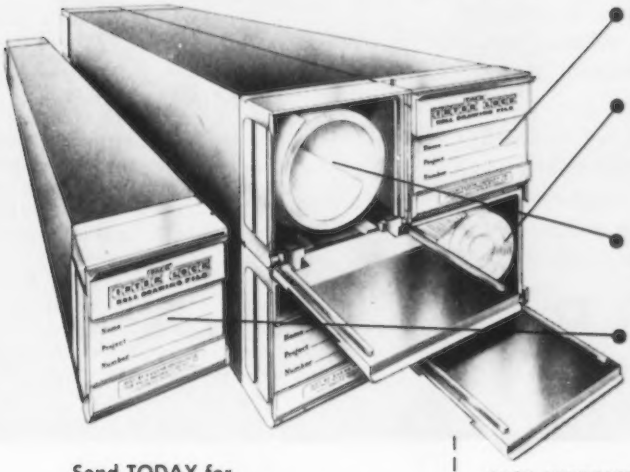
(Continued on page 96)

Install Inter-Lock units around existing files. Add-on files horizontally or vertically.

Stack Inter-Lock files right to the ceiling, if desired. Indexing on door, and cone-shaped tube opening make it easy to file, find, and remove drawings.

Pack INTER LOCK Files

Check these important advantages you get in no other filing systems:



- **SAVES FILING AND FINDING TIME.** Each drawing is finger-tip handy. Indexing and out-marking are right on file door.
- **SAVES SPACE**-puts more drawings in less space; flexible stack arrangements fit around existing files, in unused corners . . . in aisle arrangements even under tables or beside desks and drafting boards for ready-reference.
- **PROTECTS IRREPLACEABLE DRAWINGS** from dust, light, crushing, and fire damage . . . and easy access means less handling damage.
- **PERMITS ADD-ON** in any direction — for future expansion.

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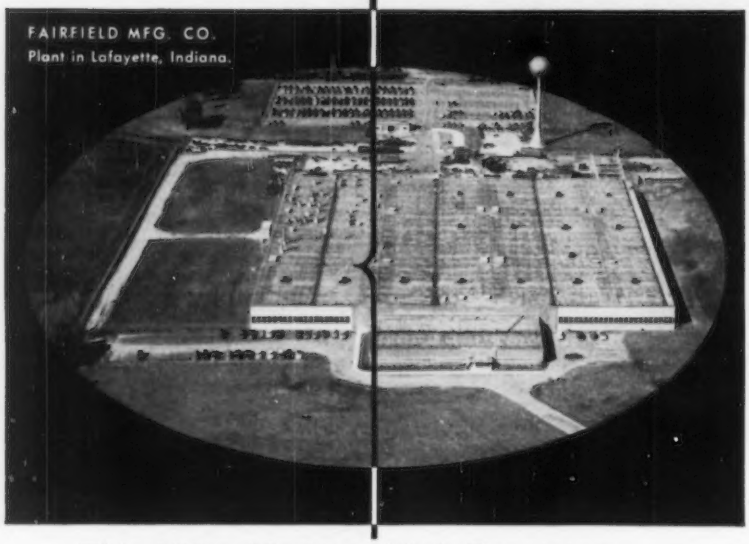

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MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS

or left-hand mounting without modification. **Gits Bros. Mfg. Co., 1850 S. Kilbourn Ave., Chicago 23.**

Circle 16, inside back cover

Silicon power rectifier . . .

for all types of power applications is a hermetically sealed unit that provides forward dc to 12 amp with a max peak inverse voltage to 500 v. For high-temperature applications, it operates at a junction temperature of 374 F with no detectable change of characteristics caused by aging. Reverse leakage of the cell is 10 milliamp max at rated inverse voltage and max temperature. Rectifier case is positive terminal and is plated to maintain low contact resistance. Can be mounted in any position. **Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30.**

Circle 17, inside back cover

Grounded sockets . . .

incorporate principles used in sealed instrument receptacles. Molded neoprene insert and gasket are one integral part, providing a completely sealed and pressurized receptacle. Socket said to be waterproof, even without a cap. Has molded-in lead construction using aircraft wire No. 16. Standard leads are 12 in. long. Three-contact socket meets UL and service requirements for power tools, appliances and electrical and electronic equipment. **Electronics Div., Whitney Blake Co., New Haven 14, Conn.**

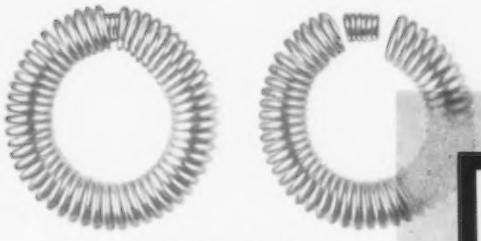
Circle 18, inside back cover

Double-acting cylinders . . .

for hydraulic service to 2000 psi have interchangeable foot lugs, center lugs, front flanges, rear flanges, and clevis-mounting steel end heads. Built in eight sizes, 2 to 8 in. inclusive, with standard

(Continued on page 99)

How a change in spring design can reduce cost and improve performance.



FIRST DESIGN

IMPROVED DESIGN

In the original conception of this switch retaining spring, an extension spring was formed into a garter spring by inserting a small plug in the form of a spring into the two ends. Assembly operation proved difficult and costly.

In the redesigned spring, one end is reduced in diameter and inserted into other end, eliminating the spring plug and providing stronger unit.

Early consultation with our spring specialists, following the determination of fundamental performance characteristics, is often insurance against unnecessarily complicated manufacture. Write for pamphlet "How to solve your spring problems." Gives case histories and valuable design considerations for various types of springs.

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
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Milwaukee Division, Milwaukee, Wis.
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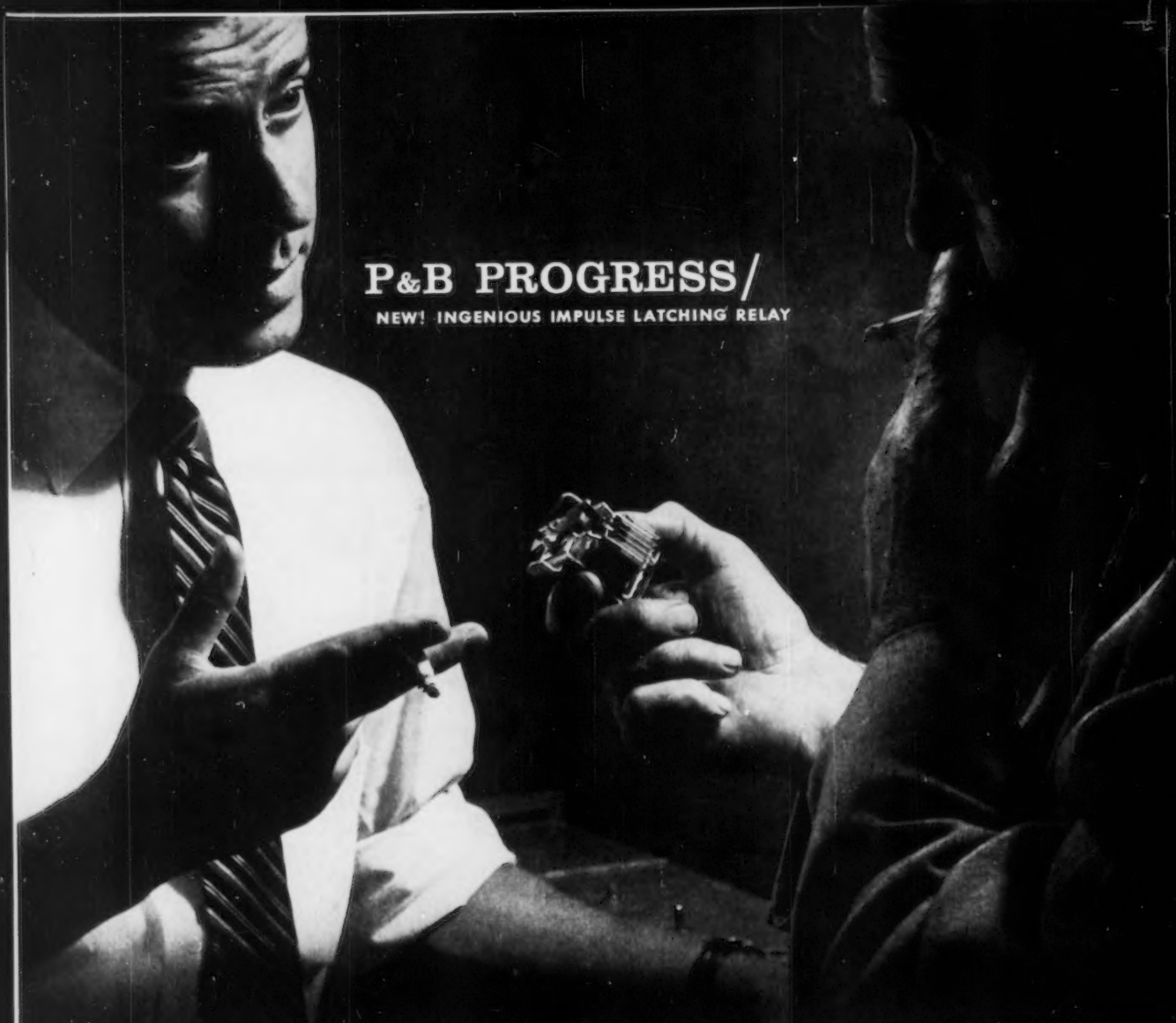
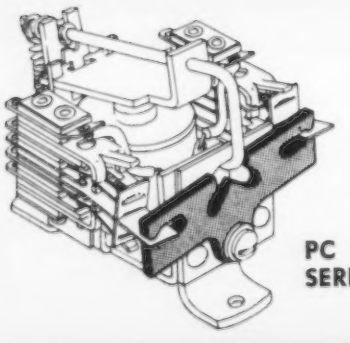
Wallace Barnes Steel Division, Bristol, Conn.
Canadian Subsidiary: The Wallace Barnes Co., Ltd., Hamilton, Ontario and Montreal, Quebec

5807 © 1958 ASSOCIATED SPRING CORPORATION



NOW! TWO-COIL PERFORMANCE AT SINGLE COIL COST!



PC SERIES

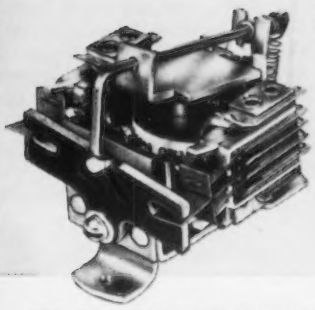
This new series, the PC, is an ingenious impulse latching relay which employs a single coil and armature to activate an insulated rocker arm. Switching is positive, fast (30 milliseconds).

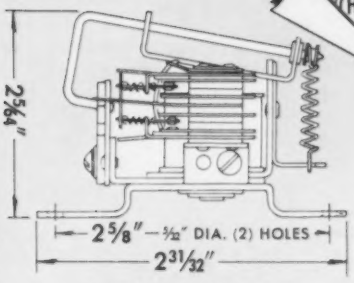
Its low cost, dependability and versatility make it ideal for a wide range of uses. For example, two leading TV set manufacturers use the PC in their remote control circuits as an "off-on" switch. It is also used by a maker of automatic garage doors. Conveying systems, automatic processing equipment, flow controls—the PC is right for these applications and many more.

Contact arrangements are available up to 4 Form C (4PDT), and the snap-action contacts are rated 5 amps. at 115 V. AC resistive. The relay may be ordered open, as shown, or in a metal dust cover.

Write or wire today for complete information.

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA / SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY





2¼" MAXIMUM WIDTH

PC SERIES ENGINEERING DATA

GENERAL: Description: Single coil, impulse latching relay.
Insulating Material: Laminated Phenolic.
Insulation Resistance: 1500 megs. min.
Breakdown Voltage: 500 V. RMS.
Ambient Temperature: —55° C. to +85° C.
Weight: 5 ozs. (open)
Pull-In: DC, 75% } for nominal voltage.
AC, 78% }
Operate: 30 MS.
Terminals: Pierced Solder Lugs
Coil: Two #20 AWG Wires
Contacts: One #20 AWG Wire
Enclosures: "A" Can.

CONTACTS: Arrangements: 4 Form C. max. (4PDT)
Material: ⅛" dia. Silver Cadmium oxide gold flashed.
Load: 5 amp. @ 115 V. AC resistive.
Pressure: 20 grms. min.

COIL: Resistance: .016 to 34,500 max.
Power: DC, 9 watts. } at nominal voltage.
AC, 18.4 Volt Amps. }
Duty: Intermittant.
Insulation: Cellulose acetate wrap; varnish impregnated (open).

MOUNTINGS: Two 13/32" dia. holes on 2⅝" center.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

Potter & Brumfield, inc.

PRINCETON, INDIANA
SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N.H.

Mail the coupon below for further engineering data on P&B's new PC Series relays *plus* new compact catalog of standard type relays. If you need answers to a specific application problem, write in detail.

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. USMC (Ret.)
Special Projects Engineer

Please send me complete data on the new PC Series relays, plus the new compact catalog of P&B standard relays.

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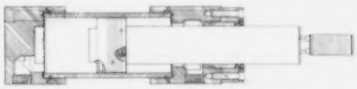
See our catalog in Sweet's Product Design File



or large rams. Strokes to 160 in. with dashpot cushions for either or both ends. Preloaded, confined cylinder seals and ram packing, unit-seal ram wiper, and bronze ram guide are used. Keeper-ring construction allows end heads to be rotated for multiple piping positions and independent head disassembly. **Oilgear Co., 1560 W. Pierce St., Milwaukee 4.**

Circle 19, inside back cover

Miniature dc motor . . .

uses a permanent-magnet field. Output is proportional to polarity and magnitude of input voltage, making this motor suitable for uses requiring a very low starting voltage, to 1½ v. Efficiency is maintained at 12 or 24-v-dc operation over a wide ambient-temperature range. Motor measures ¾ x 1⅜ in. and meets existing military specifications. **Luther Mfg. Co., 7312 Varna Ave., Hollywood, Calif.**

Circle 20, inside back cover

Glass-fiber reinforcing mat . . .

uses continuous glass fibers to achieve uniformity. Variation in binder content is held to 1% across the face of the mat. Polyester, melamine and thermosetting acrylic binders are used to achieve proper mat structure for individual applications. Available in weights of ¼ to 2 oz per sq ft in increments of ¼ oz. Comes in rolls 125 ft long and up to 72 in. wide. **Fameo, Inc., 6200 Strawberry Lane, Louisville, Ky.**

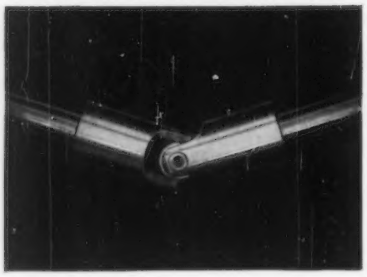
Circle 21, inside back cover

Temperature control . . .

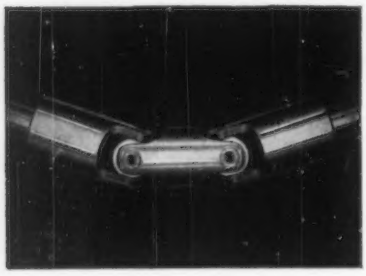
is for use in hazardous locations where explosive vapors and gases are present. Two separate switches permit switch action above or below set point, control of two independent circuits and flexibility of switching arrangement. Temperature settings are made by rotating a calibrated knob over a graduated barrel. Thermal

(Continued on page 100)

How Curtis helped a design engineer "BEAT THE HEAT"



This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not ordinarily recommend angles greater than 30°.)



Curtis engineers recommended a *double* Curtis joint, which reduced the angle to 17° per joint. Result: no overheating, improved efficiency, longer life.

You can depend on Curtis engineering in any problem of angular power transmission. And you can depend on

CURTIS UNIVERSAL JOINTS

because our catalog torque and load ratings are substantiated by constant tests under production conditions.

14 SIZES ALWAYS IN STOCK —
3/8" to 4" O.D. (6" joints on special order)

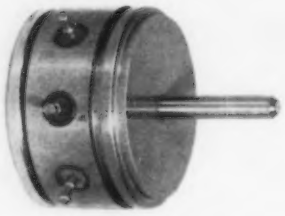
Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**
UNIVERSAL JOINT CO., INC.
11 Birnie Avenue, Springfield, Mass.
As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

system consists of a bulb, capillary and bellows filled with temperature-sensitive liquid. Bellows expands or contracts with heating or cooling, actuating a snap-action switch at a preset temperature point. Compensation for ambient temperature is effective from —65 to 160 F. A variety of switches rated for 15 amp at 115 or 230 v ac are standard. All switches are single pole and suitable for 180-F ambient temperature. **United Electric Controls Co., 79 School St., Watertown, Mass.**

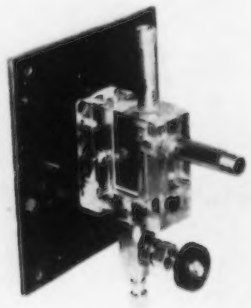
Circle 22, inside back cover



Metal film potentiometer . . .

has an alloy resistance element evaporated in high vacuum and deposited onto a ceramic disk. Thickness of the coating can be controlled to produce desired electrical characteristics. Unit withstands extreme tests of vibration, shock and humidity. Operates successfully at temperatures of 300 F. Standard power rating is 2 w at 300 F. Offered from ¼-in. to 3-in. dia. Design permits ganging and phasing of two or more independent sections on a common shaft. **Servomechanisms, 12500 Aviation Blvd., Hawthorne, Calif.**

Circle 23, inside back cover



Liquid-leak detector . . .

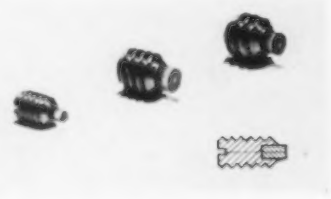
has been developed for supplemental use with existing combustible-gas or vapor-detection systems. The range of operation, however, can be extended so that the detector can be used for leak control of any organic or inorganic liquid. Available for either continuous, single-area monitoring or multipoint scanning. Circuitry is fail-safe and all units have available normally-open, common, normally-closed contacts for actuation of external devices on alarm conditions. Control cabinet designs are available for flush panelboard mounting, wall mounting or explosion proof for Class I, Group D operation. **Davis Emergency Equipment Co., Inc., 47 Halleck St., Newark 4, N. J.**

Circle 24, inside back cover

Silicone resin . . .

for cold-blending with alkyd, melamine and acrylic-type baking enamels gives them improved color and gloss retention, thermal stability and resistance to weathering. The resin is expected to find wide use as a base for aluminum paints to operate in the 500-to-1200-F range. Asbestos cloth coated with this paint can be used for heat and flame-resistant clothing; paints can be used as protective coatings. Inexpensive silicone-modified baking enamels can be prepared that offer operating advantages at temperatures in the 300-to-500-F range. Applications include coatings for transformers, motors, high temperature lamps, electrical components and appliances. **Silicones Div., Union Carbide Corp., 30 E. 42nd St., New York 17.**

Circle 25, inside back cover



Positive-locking set screw . . .

has been designed to eliminate split hub gears and clamps. A nylon insert takes the shape of the holding member and permits removal of all parts without burrs or marks. **PIC Design Corp., Sub. of Benrus Watch Co., Inc., 477 Atlantic Ave., East Rockaway, N. Y.**

Circle 26, insde back cover

Motorized reduction gearhead...

on output shaft of a motorized, stepless, variable speed reducer boosts torque rating by the amount of reduction-gear ratio. It also reduces speed range by the ratio amount. Stepless variable speed from zero to max is still maintained. Provides a motorized, geared, fully variable speed package for use where increased torque

(Continued on page 104)

HAYNES Investment-Casting Solves the *tough* design problems

INTRICATE DESIGNS
Mass-Produced Economically
...by Investment-Casting

Intricate shapes in hard-to-machine metals . . . sound metallurgical structures . . . close as-cast tolerances . . . smooth surfaces . . . are all available on a mass-production basis through HAYNES' investment-casting process. This modern mass-production method enables the design engineer to select the best alloy and most efficient design for an application. Desired parts can be made to specifications economically, regardless of how difficult or costly they might be to produce by other methods.

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For complete details, ask for our 40-page book. Write to HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, Literature Section, 30-20 Thomson Ave., Long Island City, N.Y.

Inspecting Castings—Every casting is carefully inspected to insure top quality. "Zyglo," gamma ray, x-ray, and hundreds of precision gages are available to make sure parts meet specifications.

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(Advertisement)

Special Reports On Finishing Non-Ferrous Metals

NUMBER II—Paint Base, Corrosion-Resistant Finishing with Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a good paint base and decorative finishes for non-ferrous metals. However, continued developments have been so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can obtain proper surface preparation for painting and increase product durability with a single multi-purpose chemical pretreatment. Report I on decorative, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, it is an accepted fact that metal surfaces should be prepared before painting to make possible an efficient paint system. Naturally, this preparation should provide for good initial paint adhesion. Chemical treatments have proved extremely effective in this respect, particularly those of a neutral or preferably acid nature. Further, to be most efficient, chemical treatments should provide a non-porous barrier to maintain adhesion by sealing the metal from the paint and moisture. They should also provide a self-healing film which prevents lateral corrosion in the event that bare metal is exposed through scratching.

The Iridite chromate conversion coatings meet all these requirements. Iridite is a chemical conversion treatment for surface preparation. It provides initial paint bonding by molecular adhesion. It is acid in nature and produces a film that is gel-like and non-porous in structure. Thus, the Iridite film effectively seals the metal from the paint and from moisture penetration. Because the film contains certain relatively soluble constituents, it will protect areas scratched through to bare metal and prevent lateral corrosion. This is accomplished by a gradual leaching of these constituents into the damaged area.

Further, because of its gel-like, non-crystalline nature, the Iridite film will not affect the appearance or texture of the paint film, nor will it dust or powder to mar the painted surface. Because the film is non-porous, paint coverage is increased, thus substantial savings in paint costs will be realized. In addition, treated parts may be stored for long periods of time prior to painting without the risk of entrapped moisture causing blistering when painting.

Iridite chromate conversion coatings are widely used with equal ease and success under both baked and air-dried paint systems. While the actual adherence properties of the Iridite film do not increase appreciably with its thickness, corrosion protection does. The protection of the Iridite film is proportionate to its thickness and should be taken into consideration when selecting the Iridite to meet your needs. However, it is sometimes necessary to sacrifice maximum corrosion protection for appearance when a finished part is to be only partially painted. For example, it may be desirable to use a thin, clear, bright Iridite film if the unpainted areas must present a chrome-like appearance. A typical case is that of instrument housings on which the exterior is painted and the inside left unpainted.

On the other hand, if all surfaces of the product are to be painted and maximum corrosion protection is required, the heavier and most protective Iridite films should be used. For example, all surfaces of zinc die cast fruit juicers are finished with a highly protective Iridite film prior to painting to provide maximum resistance to the corrosive action of fruit juices.

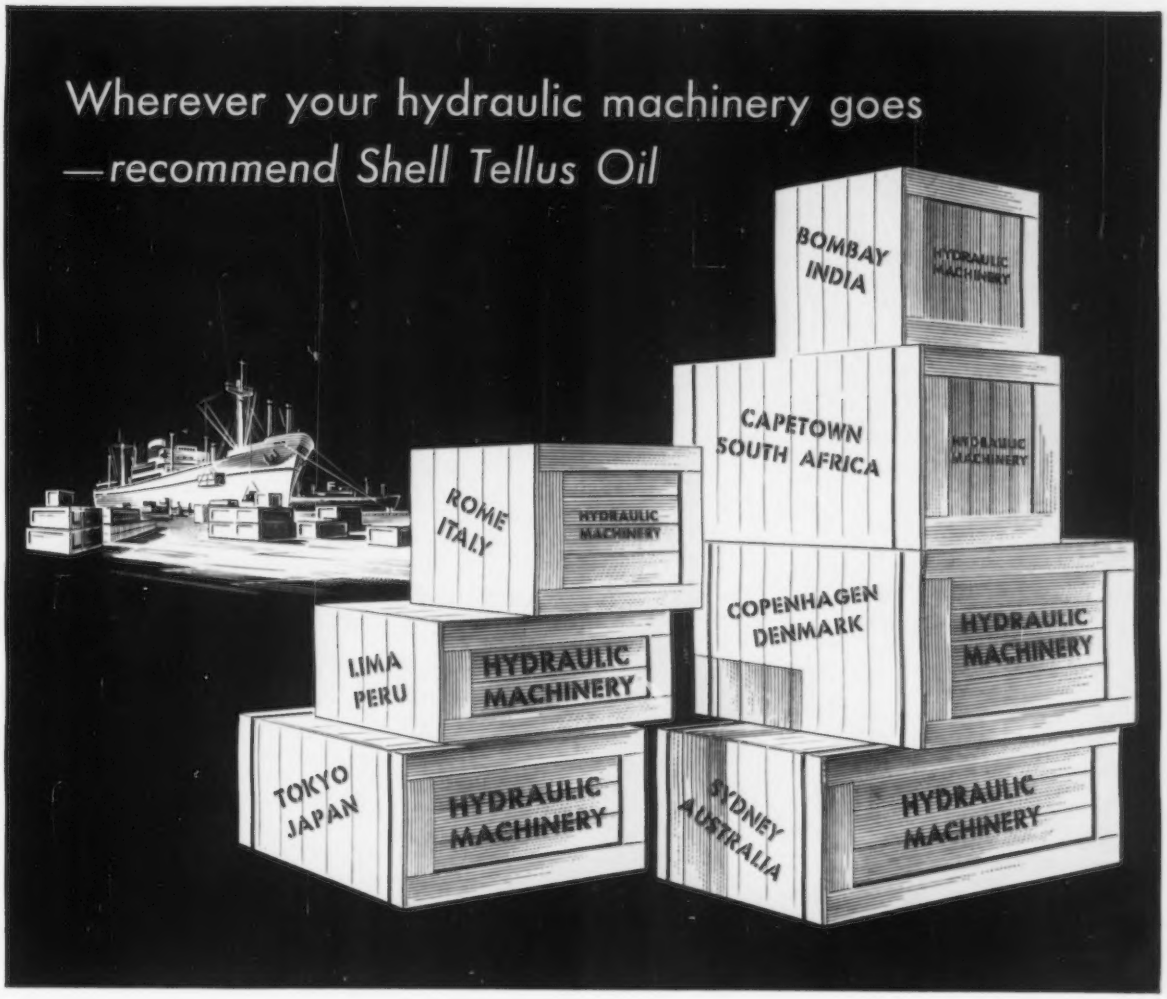
Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. In addition to providing an excellent base for paint, the Iridite films also have high decorative value when used as final finishes in themselves.

These films can produce a wide variety of pleasing appearances including clear bright, iridescent yellow, bronze, olive drab and brown. In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to their functions as protective and decorative finishes, and as bases for organic finishes and bonding compounds, Iridites have low electrical resistance. Some can be soldered and welded. The film does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.



Its performance and name are the same around the world

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Shell Rimula Oils—for heavy-duty diesel engines

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Alvania Grease—multi-purpose industrial grease

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Dromus Oils—soluble cutting oils for high-production metal working

Shell Macoma Oils—for extreme pressure industrial gear lubrication

Shell Voluta Oils—for high-speed quenching with maximum stability

Shell Tellus Oil is top-rated as both a lubricant and a control fluid for complex hydraulic systems. Its ability to combat oxidation, rust, sludge-formation, wear and foaming has earned it nationwide popularity.

You may be glad to know that the hydraulic-operated equipment you manufacture can now obtain the same efficient protection in other countries of the world. Tellus* Oil is available to your customers abroad. With it they can enjoy the same performance that your domestic customers rely upon.

For more complete information on Tellus Oil, write Shell Oil Company, 50 West 50th Street, New York 20, New York, or 100 Bush Street, San Francisco 6, California.

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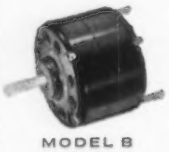
MODEL A
2-pole, shaded pole AC Induction Type



MODEL B
4-pole, 4-coil shaded pole AC Induction Type

MODEL E
4-pole, shaded pole AC Induction Type

MODEL D
4-pole, 4-coil shaded pole AC Induction Type

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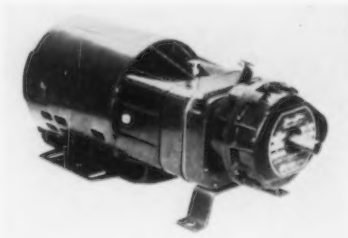


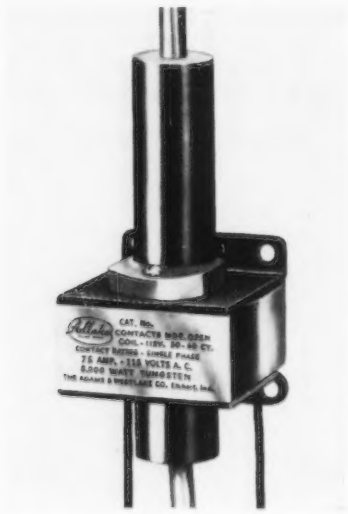
is needed without a wide speed range. Available in several combinations giving output torques from 20 to 120 in.-lb and speed ranges from 0 to 80 and 0 to 200 rpm. Standard motor is a 48-frame, 115-v, 60-cps, single-phase, open-drip-proof type. **Revoco, Inc., 1900 Lyndale Ave. S., Minneapolis 5.**

Circle 27, inside back cover

O-rings for high temperatures...

are molded from a copolymer formulation. For general dynamic or static-sealing applications with synthetic engine oils and hot fuels. Recommended high-temperature limit is 450 F, but in some applications rings are said to be serviceable to 500 F, depending upon duration of heating. Normal low-temperature limit is —40 F. Available in all standard sizes from $\frac{1}{4}$ to 16 in. OD, as well as special sizes. **Stillman Rubber Co., 5811 Marilyn Ave., Culver City, Calif.**

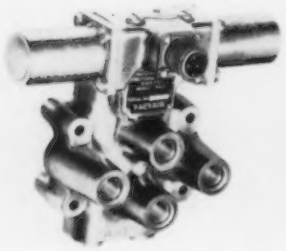
Circle 28, inside back cover



Mercury relay . . .

has 75-amp capacity in over-all dimensions of $4\frac{13}{32}$ x $2\frac{7}{16}$ x $2\frac{7}{16}$ in., based on a power factor of 75 to 80%. Relay is also rated at 8000 w tungsten. Both ratings are based on 115 v, 50 to 60 cps. Relay has a molded coil and 6-in. No. 6 flexible leads with compression lugs. Features include snap-action without pitting, sticking or burning; hermetically sealed case, quiet operation and no maintenance. **Adams & Westlake Co., Elkhart, Ind.**

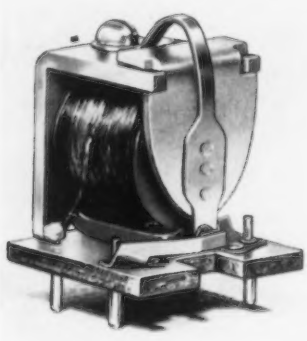
Circle 29, inside back cover



Pneumatic selector valve . . .

is a four-way solenoid-operated unit applicable where low leakage, small size, light weight and a low $\frac{1}{2}$-amp current drain is suitable. Developed for use in a rocket-release system. Operating-pressure range is from 500 to 3000 psi; normal pressure is 1250 psi; proof pressure is 4500 psi, and burst pressure, 7500 psi. It has an operating-temperature range of —65 through 160 F. The valve has a forged aluminum alloy housing and measures $2\frac{1}{4}$ x $4\frac{3}{4}$ x $5\frac{3}{8}$ in. across the solenoid. Weighs less than 1.9 lb. **Tactair Valve Div., Aircraft Products Co., 300 Church Rd., Bridgeport, Penna.**

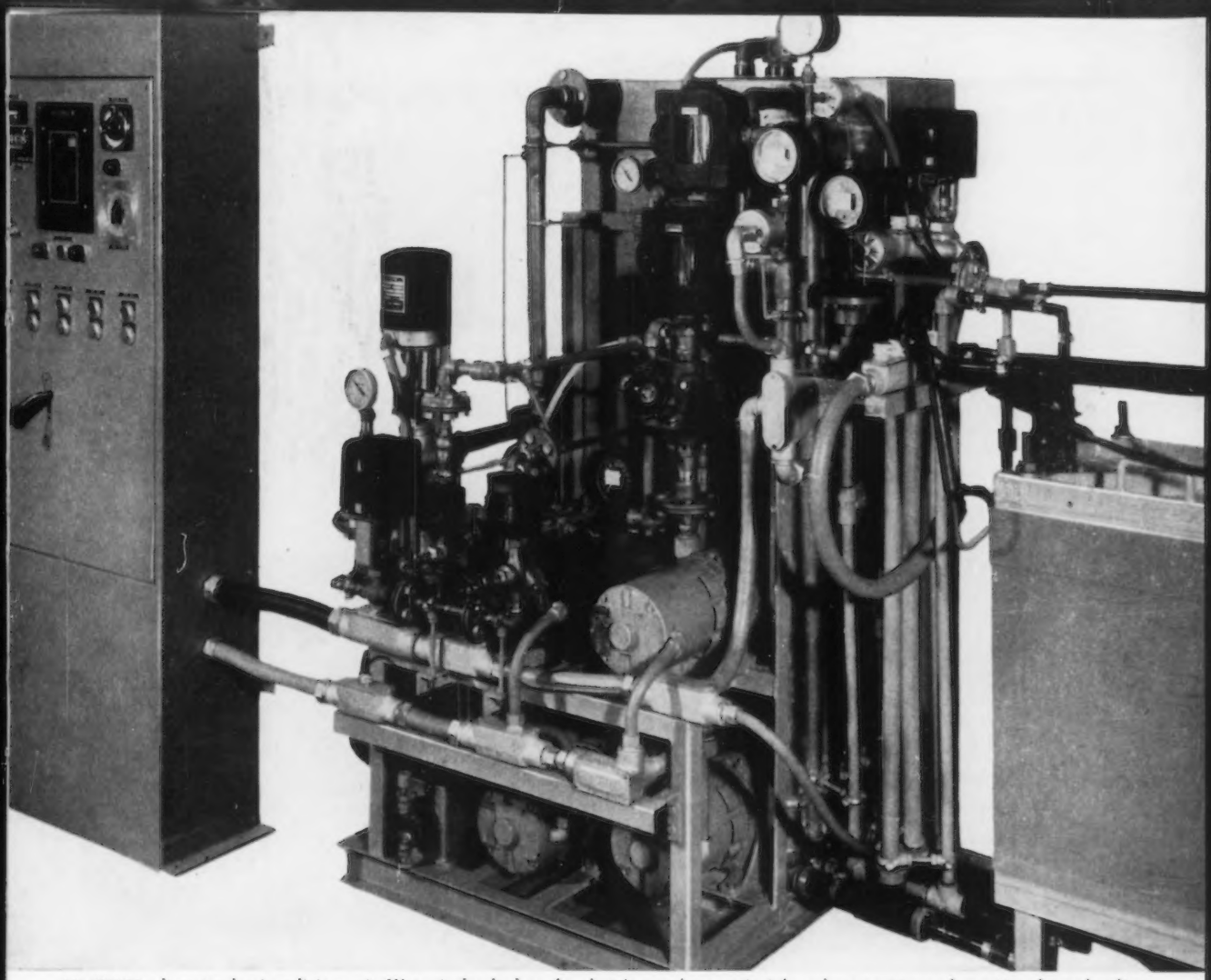
Circle 30, inside back cover



Printed-circuit relay . . .

is a SPDT unit designed specifically for printed-circuit boards. Mounting and making of electrical connections to the printed circuit are achieved in the same soldering operation that secures other components. Mounting stability is maintained by wide spacing of the silver-plated pins. Weight is about 13 gm. Palladium-inlay contacts permit positive contacting of dry-circuit

(Continued on page 106)



AN IONICS salt-water demineralizing unit. Water is desalted on the electric membrane principle—where positive and negative charged sodium and chloride ions are selectively removed from the water molecules. Note the black and gray Sealtite—from ½" to 1¼"—used here!

In remote, vital areas—Ionics demineralizers depend on Sealtite for failure-proof conduit!

More than 20 Ionics water desalting plants are now installed in water-short areas of the Middle East and United States. Units serve on radar warning platforms off our coasts.

Here—where down-time would not only be costly, but a possible major catastrophe—the electrical wiring is protected with Sealtite* flexible, liquid-tight conduit!

Sealtite takes up flexing and vibration, will not crack or break. It simplifies installation—particularly in tight quarters or where there are misaligned outlets. And its tough plastic jacket shrugs off weather, moisture, oils, and all common chemicals.

WANT TO KNOW MORE? Electrical Wholesalers stock Types U.A. and E.F.† Sealtite in easy-to-handle cartons or on reels in gray and black. Be certain you ask for and get the quality conduit marked "Sealtite" on the cover. Buy it in long lengths and cut it on the job without waste. Your wholesaler also stocks liquid-tight connectors. Free Booklet S-538 gives you full information on Sealtite. For your copy, write: The American Brass Company, American Metal Hose Division, Waterbury 20, Conn. In Canada, Sealtite is approved by Canadian Standards Association, and sold by Anaconda American Brass Ltd., New Toronto, Ont.

*Trademark. †Pat. Applied For

CUTAWAY SECTION of Type U.A. Sealtite shows tough polyvinyl jacket over flexible metal core. Copper conductor wound spirally inside conduit gives positive ground.

Insist on the conduit marked **SEALTITE**

FLEXIBLE, LIQUID-TIGHT CONDUIT

an **ANACONDA®** *product*

4 Ounce Contact Force Makes Relays More Reliable

Contact force of 4 ounces per contact on 50 "G" models and 2 ounces per contact on 30 "G" models of "Diamond H" Series R and Series S miniature, hermetically sealed, aircraft type relays is one of the most important factors in their proven high reliability.

Though absolute reliability of any similar device is impossible to guarantee—a bitter fact of life recognized by all electronic engineers—close approach to this goal by the relays manufactured by The Hart Manufacturing Company is the basic reason they are found today on many of this country's headline-making missiles.

In addition to contact force far beyond that found on other relays, "Diamond H" relays have greater contact cleanliness. Self-contamination is virtually eliminated by a completely inorganic switch mechanism, as well as use of coil materials which will not dust, flake or out-gas.

Finally, the high degree of reliability that is designed into these relays is maintained in their manufacture by high quality workmanship and a stringent inspection policy at every stage.

In addition to missiles, and their ground control systems, Series R and S relays are designed for use in jet engine controls, computers, fire control, radar and similar critical applications.

4PDT units, they offer an extremely broad range of performance characteristics, including temperature ranges from —65° C. to 125° and 200° C.; ratings to 10 A., 120 V., A. C., and 26½ V., D. C., with special ratings to 400 ma. at 350 V., D. C., or down to millivolts and milliamperes. Dry and wet circuits may be safely inter-mixed.

For more information, write today for Bulletins R250 and S260. For quick facts about "Diamond H" switches, thermostats and other devices, ask also for a copy of the "Diamond H" Check List of Reliable Controls.

THE **HART** MANUFACTURING COMPANY

206 Bartholomew Ave., Hartford 1, Conn.
Phone JAckson 5-3491

switching. Treated or untreated coils are offered in resistances to 10,000 ohm. Terminal mounting block can be furnished in glass epoxy, glass silicone or phenolic. Over-all dimensions are ¾ x ¾ x ⅝ in. high. **American Electronics Div., American-Monarch Corp., 81 N. E. Lowry Ave., Minneapolis.**

Circle 31, inside back cover

Engine mounting bushing . . .

is said to have a longer life because of a non-woven asbestos felt used in its construction. Lower cost is credited to same factor. Dimensions are 2.972 to 2.976 in. OD x 2.007 to 2.012 in. ID x 1.78 to 1.84 in. long. Applications generally call for two bushings per unit. Applications for truck and farm equipment have been approved; a variation for passenger-car use is expected. **Equipment Sales Div., Raybestos-Manhattan, Inc., Bridgeport 2, Conn.**

Circle 32, inside back cover

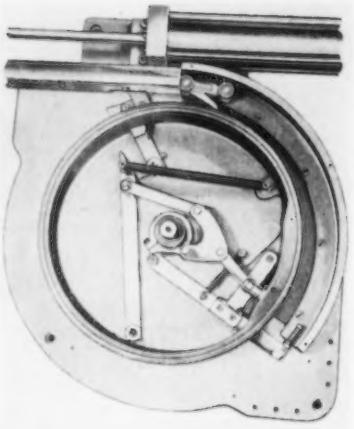
Molded tip on glow lamp . . .

for indicator-light applications permits use of longer electrodes for better end-on and side viewing. Uniformly centered tip improves appearance. Designated the NE-2E, lamp can be used in all applications where NE-2 and NE-2A glow lamps are now being used, but will occupy less space over-all lengths ¾ in. Operates on 110 to 125 v, in series with a 62,000-ohm resistor and consumes $\frac{1}{10}$ w. Lamp does not have built-in resistor. Price is about 10¢, retail. **General Electric Co., Nela Park, Cleveland 12.**

Circle 33, inside back cover

Pneumatic indexing table . . .

has a mechanical locking device that is independent of air supply. Indexing is accurate regardless of weight and size of objects on the table. The locking feature permits cylinder ram to retract during



work cycle because the ram is poised for immediate action when work is completed. The standard table will index to four, six or twelve stations. Regardless of index spacing, piston always travels to end of cylinder. Table can be vertically mounted and will work efficiently at pressures as low as 40 psi. 14-in.-dia turntable forms the base for large dial plates. Semi-automatic oiling system maintains 19 sq in. of lubricated bearing surface for turntable. **Mead Specialties Co., Dept. TT-P44, 4114 N. Knox Ave., Chicago 41.**

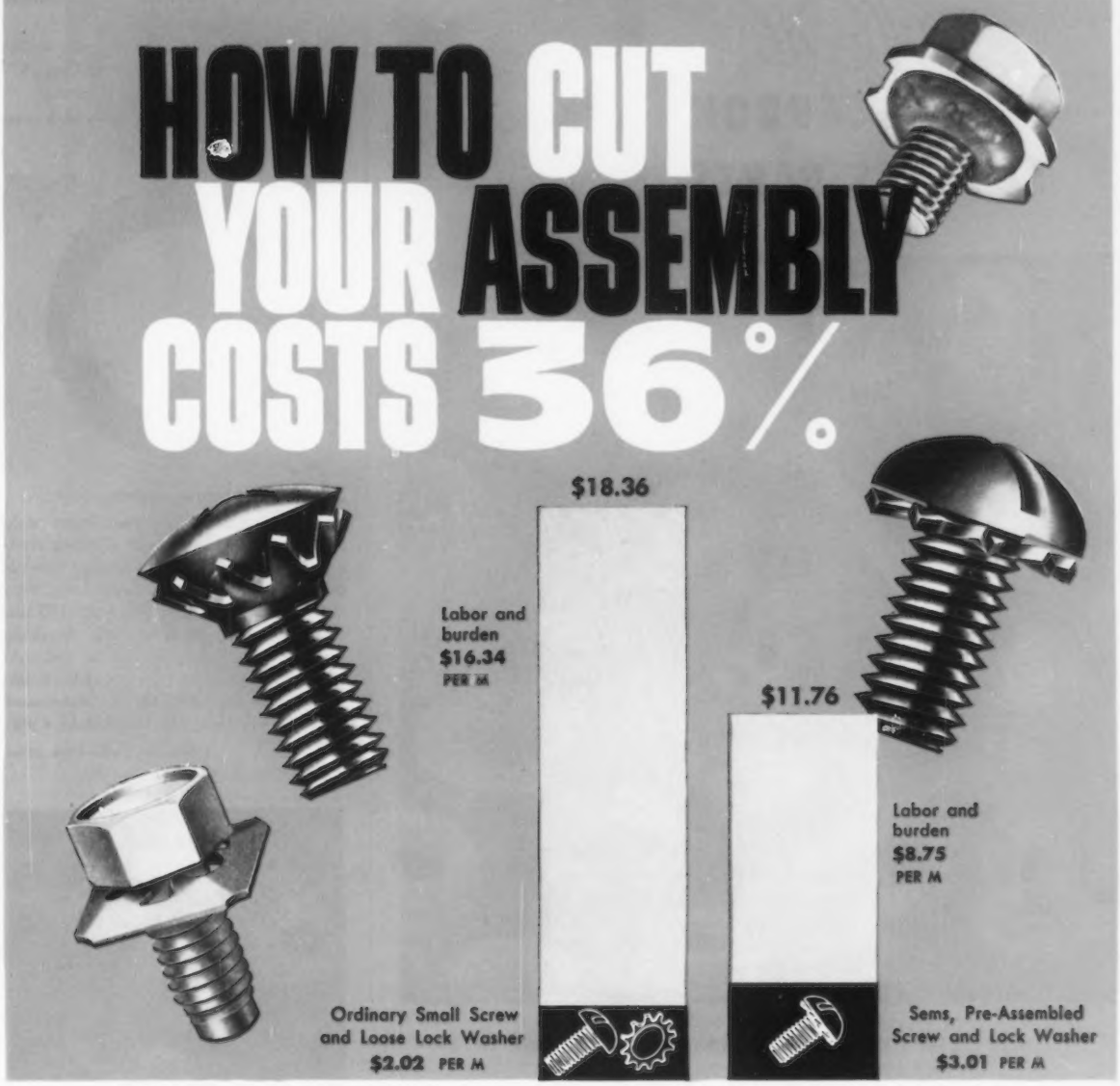
Circle 34, inside back cover

Variable-area flowmeter . . .

has packing-less, snap-in metering tubes that permit coverage of flow ranges from a fraction of a cc per min to 40 gpm, with only three meter sizes. Nuts, bolts, stuffing boxes, packing glands and adjustments have been eliminated by using O-rings to seal tube ends to metal fittings. Piping strains cannot be transmitted to the glass metering tube because the tube floats in the O-rings. Side frames and front and rear covers are also of snap-in

(Continued on page 108)

HOW TO CUT YOUR ASSEMBLY COSTS 36%


$18.36
Labor and burden $16.34 PER M
$11.76
Labor and burden $8.75 PER M
Ordinary Small Screw and Loose Lock Washer $2.02 PER M
Sems, Pre-Assembled Screw and Lock Washer $3.01 PER M

SEMS-by-SHAKEPROOF, mechanically pre-assembled washers and screws, eliminate separate washer handling on the production line . . . save you time and money. Here's proof:

The total cost of using separate washers and screws averages $18.36 per thousand, as the above chart shows. Switching to Sems reduces the labor and burden cost substantially, since hand assembly of washer and screw is eliminated. This brings down the total fastening cost to $11.76—a savings of 36%—even though pre-assembled Sems are priced slightly higher.

Even greater cost-savings result in the use of special Sems. Among the many types available are: high-strength Dished and Domed lock washer Sems; Countersunk lock washer Sems; fiber, asbestos or rubber washer Sems; Flat and Conical washer Sems; 3-piece terminal-clamp Sems; mastic sealing Sems; and a large variety of special washer and screw combinations.

Shakeproof recently concluded an analysis of fastening applications showing that the price of common fasteners is only 19% of the total cost, while labor and burden required to "install" the fasteners represent 81% of the total cost. This study proves that greater savings can be made with labor-saving fasteners than with fasteners purchased on the basis of lowest price per thousand.

To learn more about this concept of assembly savings, write for the Shakeproof "Price-Per-Thousand" booklet.

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For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses throughout the U.S. and Canada, or write

United States Gasket Company
Camden 1, New Jersey

United States Gasket *Plastics Division of* **GARLOCK**

construction. Dimensions conform to ISA standards. **Fischer & Porter Co., 577 Jacksonville Rd., Hatboro, Penna.**

Circle 35, inside back cover

300°-movement meters . . .

for panel mounting increase linear scale available and permit more accurate readings. Response and dampening time is said to be three to four times faster than 90° types. Standard ranges from 100 microamp up can be furnished. Available with accuracies of 1 to 2% of full-scale value, 2½, 3½ and 4½-in. sizes. Meters are hermetically sealed. **Miller Instrument Co., 165 E. Lincoln St., Escondido, Calif.**

Circle 36, inside back cover

Instrument panel clock . . .

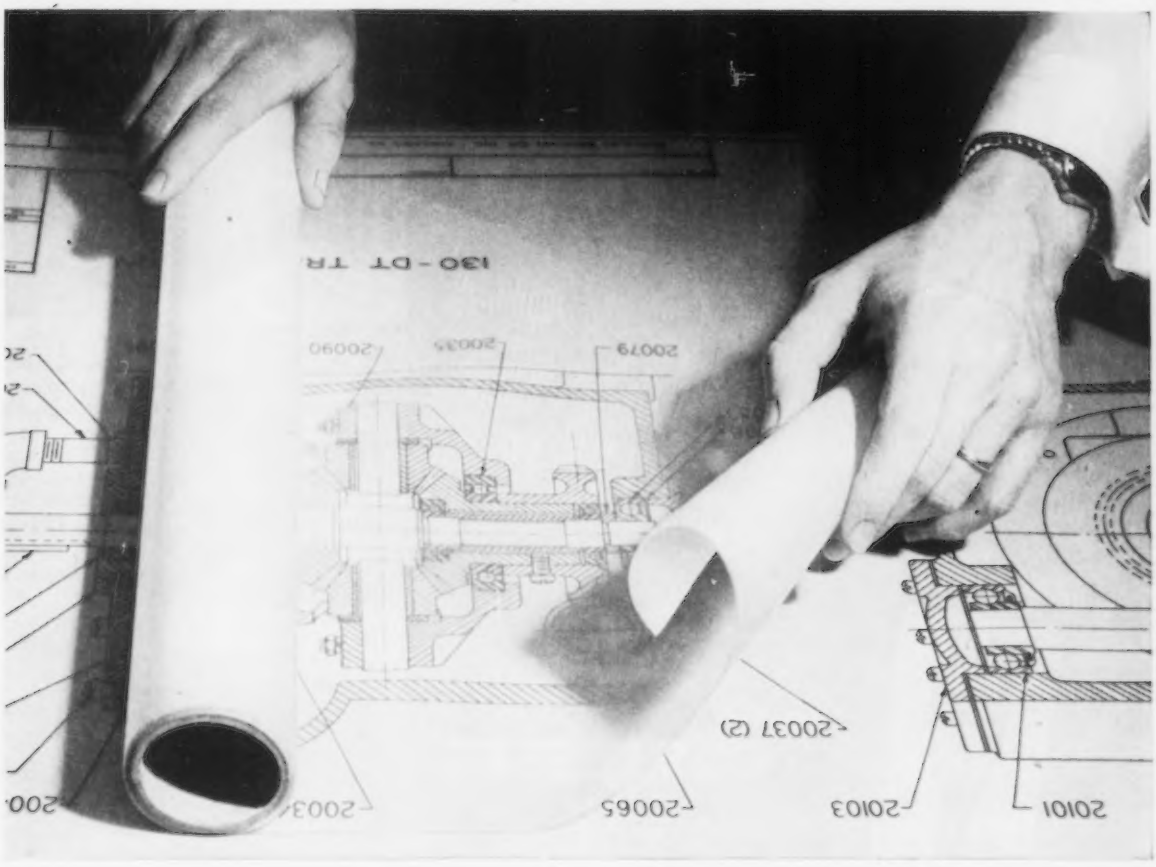
manufactured to military specs is suitable for instrument, recording and photographic applications. Shock-resistant as well as waterproof and chemical-resistant. **PIC Design Corp., Sub. of Benrus Watch Co., Inc., 477 Atlantic Ave., East Rockaway, N. Y.**

Circle 37, inside back cover

Dc-to-ac converter . . .

delivers 2000 w ac from 32-v storage battery. For heavy-duty performance in applications requiring high-capacity output of 115 v or 230 v ac, 50 or 60 cps, single or three-phase. Converters operate from 32, 48, 64, 115 or 230 v dc. Four-pole

(Continued on page 110)



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Stock carried

design permits an armature operating speed of 1800 rpm. Marine-grade specs are standard throughout. Dripproof ventilated housing has steel-frame ring with aluminum end castings. Over-all size is 11 x 19 x 12 in. high; weight 195 lb. Prices range from $595 for the 1000-w model to $690 for the 2000-w unit. **Carter Motor Co., 2711 AW. George St., Chicago 18.**

Circle 38, inside back cover

Mylar drafting sheets . . .

with either grid or cross-section have a printed area of 20 x 30 in., 8 or 10 lines per in. Accuracy is said to be to ±0.005 in. The matte-finish Mylar acts as a surface for pressure-sensitive tapes in the preparation of master drawings for mechanical layouts. Nonreproducible blue lines provide accurate scale line during plotting, but do not reproduce. **Chart-Pak, Inc., 3 River Rd., Leeds, Mass.**

Circle 39, inside back cover

Propelling drawing pencil . . .

has flat-ribbon lead inserts, 0.016 thick and 0.047 wide, for work on graphs, charts, plans and drafting. Form-fitting knurled shaft of hard rubber handles easily. Top of the pencil is stamped and various colored rings supplied for identification of different grades of lead hardness. Supplied in a box with a tube of 1 doz leads at $2.75. **Alvin & Co., Windsor, Conn.**

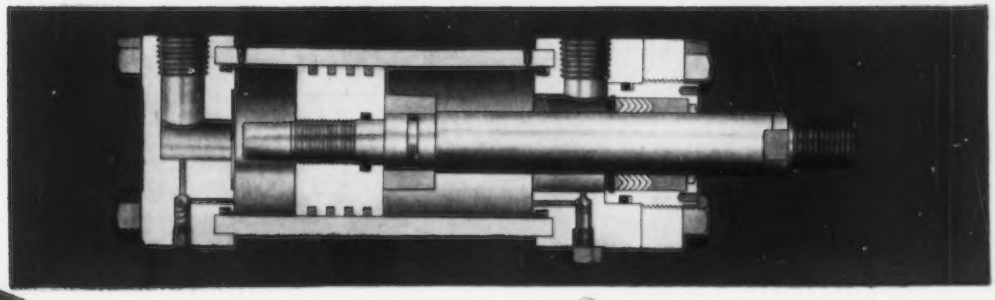
Circle 40, inside back cover

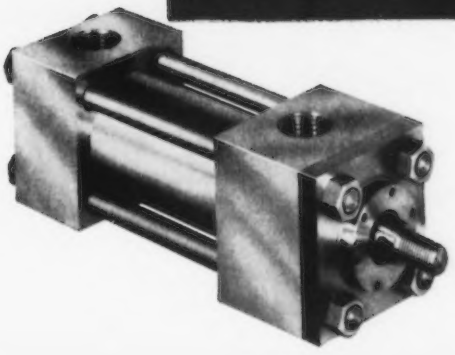
Rectifier power supply . . .

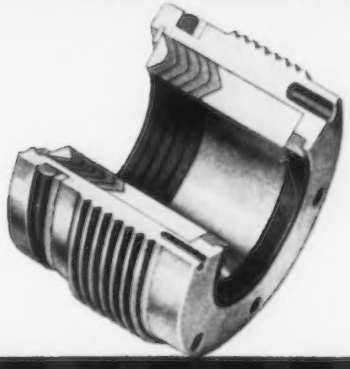
has a continuously adjustable output of from 0 to 110 v dc with a max load-current rating of 20 amp. Ripple does not exceed 1% of average dc output throughout range of the equipment. Regulation is 5 to 6% from $\frac{1}{10}$ load to full load at 110 v output. Housed in a ventilated

(Continued on page 112)

O-M a Power-Full Idea in High Pressure Hydraulic Cylinders







O-M *Series TH*
Heavy Duty Hydraulic Cylinders 2000 PSI Shock Loads 3000 PSI Non-shock Loads Meet JIC Standards

Tested, tried and proved powerful components in today's fast-moving automation picture, these ruggedly constructed O-M Heavy-duty Hydraulic Cylinders breeze through heavy work loads, withstand shocks and strains, and provide smooth, dependable power for a wide range of pressures and operating conditions.

Important design and construction features:

1. Head Seal—"O" Ring with leather back-up washer assures positive seal between head and tube.
2. Heads confine tubing O.D. to prevent breathing and thereby provide additional insurance against leakage under the most severe conditions.
3. Heads are counterbored to pilot in accurately honed tubing to assure perfect alignment.
4. Multiple lip, self-compensating, Vee type rod gland packing.
5. Step-cut ring type pistons are standard, but Vee type pistons are available for holding application.
6. Rod gland cartridge is removable for easy maintenance.

O-M Series TH High Pressure Hydraulic (oil) Cylinders are available in full range of sizes (1½" to 8" bores) with standard and heavy duty piston rods.

Mail Coupon TODAY for Bulletin 105 showing descriptive drawings of cylinders, mounting accessories and capacity chart.

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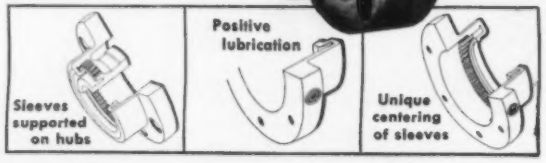
FAST'S Model B Coupling



reduces downtime and upkeep for light-to-medium drives!

Now you can profit from the durability and economy of famous Fast's couplings in a smaller and lower-cost version—available in 5 sizes for shafts ½" to 3⅛" in diameter.

The Model B coupling gives you the same features that have made Fast's the world's leading coupling for over 35 years. You get the same trouble-free performance, longer service life and lower maintenance costs. You also get prompt delivery because stocks are on hand to meet practically every need. Free engineering service is also available.

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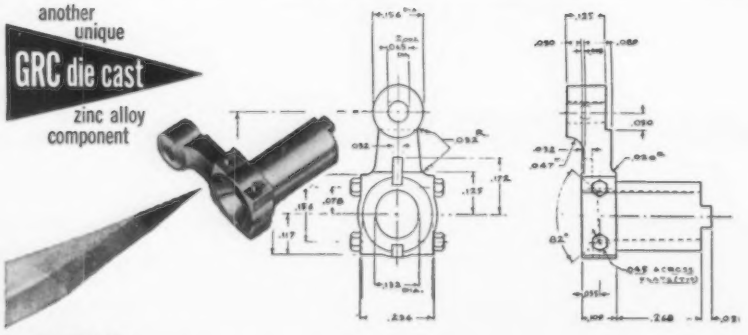

GRC die casting helps Lionel achieve tiny part authenticity

This intricate toy crank was die cast in zinc alloy by GRC in a single automatic operation. Cost? Little more than $5.00 per thousand in lots of 500,000. Result? Produced quicker and more economically than Lionel could themselves.

Less than half an inch overall, it is typical of the many small (maximum is 1¾" ½ oz., no minimum) parts problems solved by GRC's unique techniques. Gries' specialized machines deliver parts ready for use—uniform, accurate, clean—no trimming, no assembly, no scrap loss.

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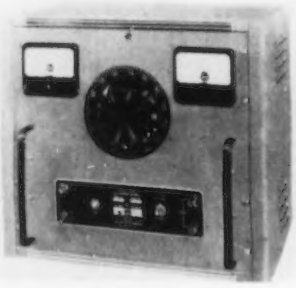


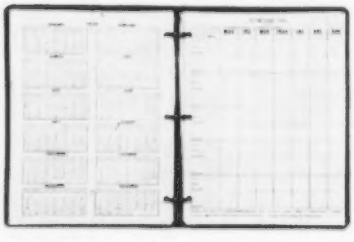
rack cabinet, 22 x 19 x 15 in. deep. Also available for mounting in a standard 19-in. wide rack. **Opad Electric Co., 69 Murray St., New York 7.**

Circle 41, inside back cover

Lathe-cut rubber rings . . .

for sealing applications are available in various compounds. The synthetic-rubber, rectangular-cross-section rings are cut to closer tolerances than ordinary lathe-cut rings, according to the manufacturer, making the rings suitable for many gasket applications. **Parker Rubber Div., 17325 Euclid Ave., Cleveland 12.**

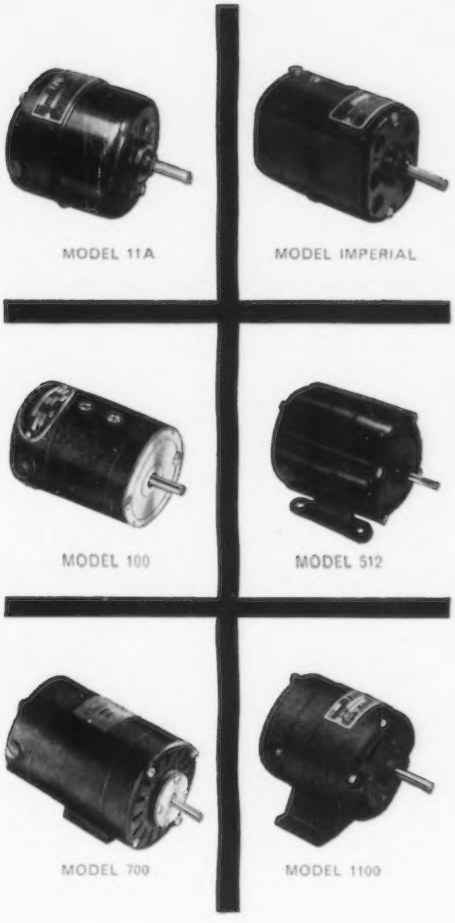
Circle 42, inside back cover



Scheduling aid . . .

for engineers and designers is this worksheet in 8½ x 11 in. format to fit three-ring binders. Each sheet handles five jobs for a 1-wk period. By using succeeding sheets, work may be scheduled for 6 mo or longer. A complete calendar is printed on the back of each schedule. Provision has also been made to note actual progress of work from day to day. **Air-Com Printers, 6428 Crenshaw Blvd., Los Angeles 43.**

Circle 43, inside back cover



MORE THAN *50,000* *DIFFERENT SPECS* HAVE BEEN FILLED BY THESE 6 HOWARD UNIVERSAL AND D.C. FRACTIONAL H.P. MOTORS

These 6 Howard motors account for over 50,000 specifications, both military and commercial. One reason for this wide use is Howard's ability to produce variations *exactly* suited to specific needs.

Howard motors have such field-proven engineering features as automatic slot cell insertion, which practically eliminates "grounds;" Zanderoll processed double dipped and double baked armatures providing deep, uniform varnish penetration for high bond strength and rock-hard coils minimizing "shorts and opens;" improved brushholder construction for accurate alignment and longer life; 2-stage, 3-plane dynamic balancing; and automatic winding for tough compact coils, giving uniform performance.

If you are currently using universal and D.C. motors from 1/200th to ½ H.P., check with Howard today.

GEAR REDUCTION UNITS

Model	Ratio	
	min.	max.
11A	3:1	2700:1
Imperial	3:1	2700:1
100	3:1	2700:1
512	3:1	2700:1
700	21.5:1	2600:1
1100	3:1	2700:1

ELECTRICAL SPECIFICATIONS

	MODEL 11A		MODEL IMPERIAL		MODEL 100		MODEL 1100		MODEL 512		MODEL 700	
	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR
NO LOAD SPEED (RPM)	15M	3.5-10M	16M	3-10M			15M	3.5-10M	15M	2-9M	16M	9M
FULL LOAD SPEED (RPM)	5-10M	3-8M	5-10M	1.5-8M	5-10M	1.8-6M	5-10M	3-8M	5-10M	1.8-6M	5-10M	1.8-6M
MAX. H.P. CONT. @ MAX. R.P.M.	1/75 No Fan	1/75 No Fan	1/15	1/20	1/50	1/50	1/50	1/50	1/10	1/12	1/4	1/8
MAX. H.P. INTER. @ MAX. R.P.M.	1/20	1/20	1/4	1/10	1/13	1/13	1/15	1/15	1/5	1/6	1/2	1/4
FULL LOAD AMPS. CONT. @ 115V.	.4	.4	1.1	1.1	.35	1.6 at 24V	.40	.45	1.5	1.5	3.2	1.7
FULL LOAD AMPS. INTER. @ 115V.	.75	.75	2.0	2.0	1.0	5 at 24V	.70	.90	3.0	3.0	6.6	3.0
% EFF. AT FULL LOAD CONT.	30	30	35	30	35	35	60	35	50	45	60	50
% EFF. AT FULL LOAD INTER.	35	35	50	45	45	45	45	45	60	55	65	55
VOLTAGES	12-115	6-120	24-115	6-120	12-120	6-32	12-230	6-120	24-230	12-230	24-115	6-230
ROTATION	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.

Maximum H.P. ratings are shown. Variations are available for less power to meet application requirements.

Other Howard motors: UNIVERSAL & D.C. 1/200 to 1/2 h.p. • SHADED POLE 1/2000 to 1/8 h.p. INDUCTION 1/1400 to 1/8 h.p. • SERVO MOTORS • GEAR MOTORS • BLOWERS

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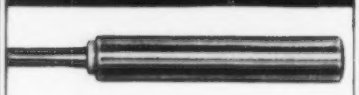

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 119.

PANEL DESIGNING—Handbook EE-120-B, 68 pp. Data on designing panels for the control of machines and machine tools. Material is arranged in order of simplicity of function, starting with manual relays and contactors and on through electrical interlocks and solenoid-operated brakes. For each item listed, there are illustrations, diagrams, dimensions, ratings, catalog numbers and ordering information. Cutler-Hammer, Inc., 296 N. 12th St., Milwaukee 1.

Circle 44, inside back cover

SIZE 15 SERVOMOTOR—Data Sheet 1258, 4 pp. Introduces new 115-v, 400 cps, size 15 servomotor. Details are given on characteristics and construction. With dimensional data and drawings. Helipot Technical Information Service, Newport Beach, Calif.

Circle 45, inside back cover

AUTOMATION CYLINDERS—Bulletin SS-58, 4 pp. Gives dimensions for 11 models that comprise S-2 Series. Includes mounting and ordering data. With dimensional drawings. Hydro-Line Mfg. Co., 5600 Pike Rd., Rockford, Ill.

Circle 46, inside back cover

CONTROLLED PRELOAD FASTENER—Brochure, 4 pp. Describes advantages, gives specs, discusses tooling. With curves, charts and dimensional drawings. Hi-Shear Rivet Tool Co., 2600 W. 247th St., Torrance, Calif.

Circle 47, inside back cover

POWER - TRANSMISSION EQUIPMENT—Catalog 100, 80 pp. Information on stock gears, speed reducers, sprockets and chains, flexible couplings, universal joints, collars and pillow blocks. Illustrated with photos and dimensional drawings. Charles Bond Co., Gear Div., 617-23 Arch St., Philadelphia 6.

Circle 48, inside back cover

ELECTRIC BRAKE APPLICATIONS—Bulletin GET-2770, 8 pp. Applications, performance, operation and characteristics of solenoid-operated, and magnet-operated brakes. Included are 16 performance curves. General Electric Co., Schenectady 5, N. Y.

Circle 49, inside back cover

DRIVE-PIN BLIND RIVETS—Data file, with 16 pp catalog and three bulletins. Describes applications of a new line of rivets. Includes technical data, dimensions and weights. Deutsch Fastener Corp., P. O. Box 61072, Los Angeles 61.

Circle 50, inside back cover

INDICATING, RECORDING, CONTROLLING THERMOMETERS—Catalog C60-2, 56 pp. Describes line of rectangular, case-filled system thermometers. Gives design features, operating principles, specs and individual listings for thermometers and accessories. Industrial Div., Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44.

Circle 51, inside back cover

SHAFT-MOUNTED DRIVES—Bulletin 7100, 32 pp. Includes description of unit design and construction, suggestions on applications, installation data and selection information. Data, too, on sheave and belt selection and accessories. The Falk Corp., Dept. 255, 3001 W. Canal St., Milwaukee 1.

Circle 52, inside back cover

AUTOMATIC VALVES—Bulletin 7F, 4 pp. Quick-reference data on several pressure-reducing and regulating valves, back-pressure valves and diaphragm-operated control valves. Gives available pressures, body materials, service and pipe sizes. Cash-Acme, P. O. Box 191, Decatur, Ill.

Circle 53, inside back cover

WELDED STEEL TUBING—Brochure, 4 pp. Lists sizes, gages and finishes. Typical uses are given. Also, information on engineering services. Southern Fabricating Co., Inc., Sheffield, Ala.

Circle 54, inside back cover

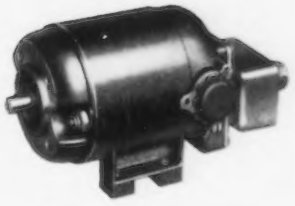
ALUMINUM FABRICATION – Chart Sec. GG, No. 1, 2 pp. Covers government specs and information on bending and forming of aluminum sheet and plate. Printed on cardboard stock, regular file-card size. Peter A. Frasse & Co., Inc., 17 Grand St., New York 13.

Circle 55, inside back cover

VARIABLE-SPEED DRIVES—Brochure, 8 pp. Illustrates and describes line of

(Continued on page 116)

PASSES TESTS WITH FLYING COLORS



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Impact concrete drill motor.

. . . equal dependability for your product

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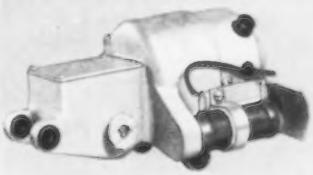

Gear motor for slow-speed drive.

If you are interested in any of the above motors write and we shall be glad to send full information.

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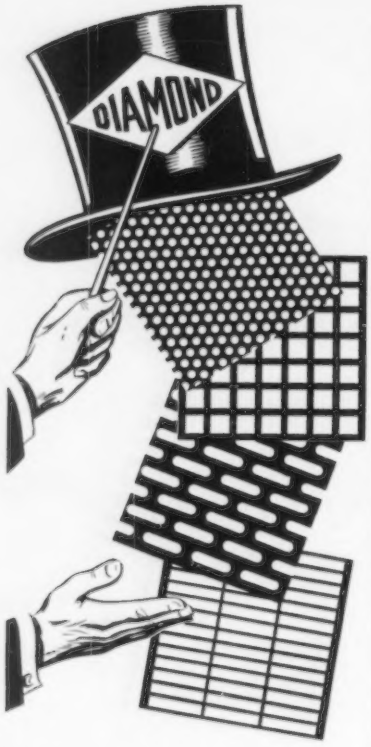

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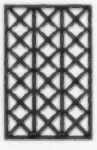
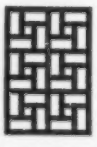
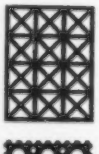
The popular Diamond Perforated-metal patterns shown above are only a few of the many illustrated and described in our 32-page Catalog No. 39. All of these standard patterns are available in a wide range of unit-opening sizes and we are always equally pleased to quote on original designs of any type or size.





Catalog 39 also illustrates and describes our high-quality lines of *Ornamental Cane*, Perforated-Metal Sheets for Accoustical installations and Heavy-Duty Architectural Grilles. Write, today, for a free copy.



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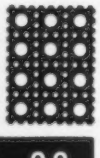

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West Coast Plant,
DIAMOND PERFORATED METALS CO.
17935 So. Figueroa St., Gardena, California
Los Angeles Area

drives; gives application and design advantages. Includes large cutaway illustration. Sterling Electric Motors, Inc., 5401 Telegraph Rd., Los Angeles 22.

Circle 56, inside back cover

VARIABLE-SPEED DRIVE PACKAGE—Bulletin 1257-1, 4 pp. Describes operation and applications of the unit, which has no tubes, no brushes, no commutator. Fidelity Instrument Corp., 1000 E. Boundary Ave., York, Penna.

Circle 57, inside back cover

TEMPLETS—Catalog 60, 12 pp. Photos and descriptions of the 91 templets now available. An index lists the templets by number and category. Catalog is divided into seven sections: electrical, ellipses, mechanical engineering, general, architectural, processing, and miscellaneous. Rapidesign, Inc., Box 429, Burbank, Calif.

Circle 58, inside back cover

PNEUMATIC TRANSDUCER—Catalog sheet 59-100, 2 pp. Explains operation of electromechanical device for converting 3-15 psi input pressures into ac signals. Fischer & Porter Co., 495 Jacksonville Rd., Hatboro, Penna.

Circle 59, inside back cover

ELECTRIC MOTORS—Catalog P-86012, 8 pp. Lists, illustrates and describes a line of flip motors—split-phase, capacitor-start, polyphase and other types. Franklin Electric Co., Inc., Bluffton, Ind.

Circle 60, inside back cover

WIRE-CLOTH-PRODUCT DESIGN—Multi-scale slide rule gives direct readings of the percent of open area of any wire cloth, providing flow-rate data required in filtration applications. Also, other scales facilitate determination of data of interest to wire cloth fabricators and designers. Reynolds Wire Div., National-Standard Co., Dixon, Ill.

Circle 61, inside back cover

PRESSURE COMPARATOR—Catalog sheet 32CA110, 2 pp. Explains operation and construction of unit. Includes cross-section view of the comparator. Fischer & Porter Co., 496 Jacksonville Rd., Hatboro, Penna.

Circle 62, inside back cover

CORROSION-RESISTANT FASTENERS—Net-price catalog, 84 pp. Lists all sizes of every standard item in the line plus extra stock items. Issued four times a year. H. M. Harper Co., 8299 Lehigh Ave., Morton Grove, Ill.

Circle 63, inside back cover

SYNCHROS—Data sheet, 6 pp. Presents characteristics of synchros, servomotors, resolvers, motor tachometers and tachometer generators. Is a reference key to more detailed data sheets. Muirhead Instruments, Inc., 677 Fifth Ave., New York 22.

Circle 64, inside back cover

ROTARY SOLENOIDS, SWITCHES, SELECTORS, STEPPING MOTORS—Bulletin 1157LS, 4 pp. Describes rotary solenoids, selector switches, hermetically sealed selectors and stepping motors. Contains a dimension and torque chart for stock solenoid models, a cutaway drawing of the stepping motor, dimensional data on selector switches and a brief review of sealed selectors. G. H. Leland, Inc., 123 Webster St., Dayton 3.

Circle 65, inside back cover

PLUG-IN SERVO SYSTEMS—File folder containing brochure and specification sheets. Gives information on plug-in servo repeater systems, subminiature servo amplifiers and the concept of coordinated miniature systems and components. Waldorf Instrument Co., Huntington Sta., Long Island, N. Y.

Circle 66, inside back cover

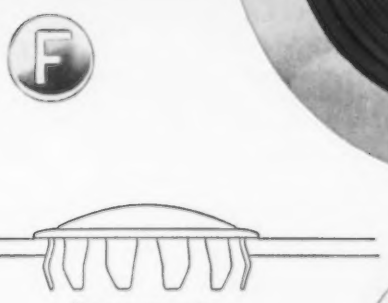
AC-MOTOR SIZES—Catalog sheet, 2 pp. Gives NEMA frame assignments and overall dimensions of ac motors in new NEMA frames sizes from 364 U to 445U. Explains how to compare dimensions of Series C motors with those of Series D. Reliance Electric and Engineering Co., 24701 Euclid Ave., Cleveland 17.

Circle 67, inside back cover

DIE-CAST THREADED FASTENERS—Catalog 8 pp. Describes line of standard stock fasteners. This includes many types obtainable only on special order from many sources. With photos, specs and

(Continued on page 119)

"No raise, but they gave me a goose-neck lamp for my desk!"



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Available in clear or colored plastics... brass or steel in all standard finishes... embossed and enamel-filled or molded to show company insignia or other identification symbols . . . Dot plug buttons snap into place and stay where they're put even under conditions of extreme vibration. Yet they can be removed and replaced repeatedly without damage.

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dimensional drawings. A special section discusses injection-molded nylon fasteners. Gries Reproducer Corp., 125 Beechwood Ave., New Rochelle, N. Y.

Circle 68, inside back cover

Letterhead Requests Only

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

HYDRAULIC DATA—Bulletin 3300, 40 pp. Furnishes conversion tables, decimal equivalents, hydraulic-ram capacities, wire and sheet-metal gages, steel-pipe tables, bolt tables, specific gravities and strengths of materials. Also provides data on fluid losses, properties of metal sections, beam formulas, methods for finding moments of inertia of various sections, deflection curves for springs, temperature-conversion tables and hardness-conversion tables. Hydraulic and Compacting Press, Hamilton Div., Baldwin-Lima-Hamilton Corp., Hamilton, Ohio.

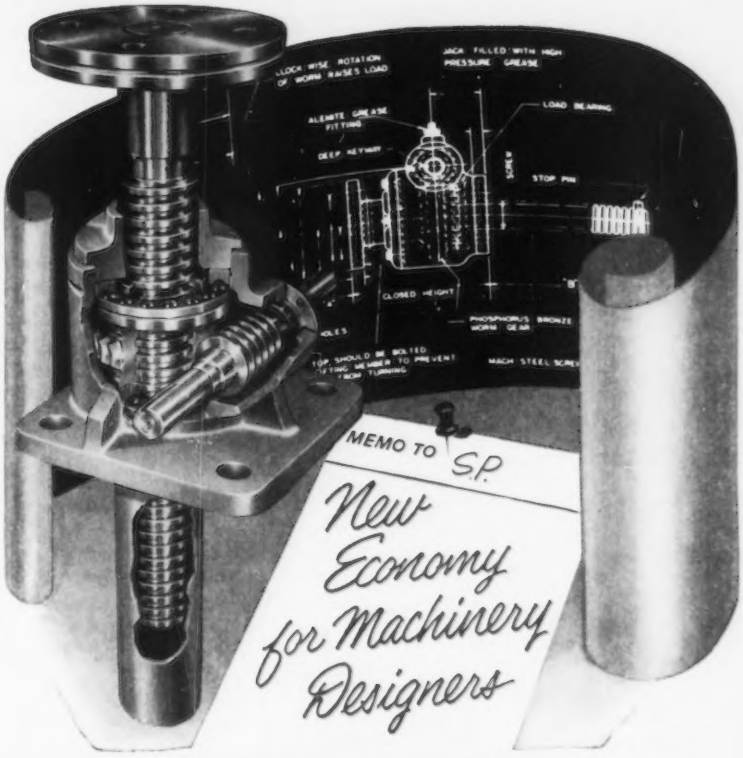
INDUSTRIAL CASTERS – Standards CFT-C1-58, 8 pp. Gives standards of interchangeability of casters, including standard size and dimensions for casters and wheels and general-duty classifications by sizes. Discusses the problems of caster selection. With illustrative diagrams. Caster & Floor Truck Mfr. Assn., 27 E. Monroe, Chicago 3.

EXTRUDED PLASTICS—Brochure, 12 pp. Information on complex shapes, rods, tubes, moldings. Describes fabricated parts, discusses thermoplastic materials suitable for extrusion and gives material-property tables. Applications are shown. Anchor Plastics Co., Inc., 36-36 36th St., Long Island City 6, N. Y.

AUTOMATIC CONTROL EQUIPMENT—Catalog 18, 64 pp. General information, specs dimensions and prices. Applications, construction details and operating features are included. Indexed in four sections, covering automatic transfer switches, contactors, special controls and timing devices. Zenith Electric Co., Dept. PEN, 152 W. Walton St., Chicago 10.

File copies . . .

of selected articles from this and other recent issues are now available in convenient reprint form. Single copies are offered without charge to readers in U. S. and Canada as long as the supply lasts. See complete listing in "Current Reprints" on page 127, and use one of the postpaid Reader Service cards to receive the copies you need.



NOW, A STANDARD LINE OF DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-DD, which includes drawings and full specifications.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

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Hydraulic, Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever
Spur Gear, Electric

DESIGN ABSTRACTS

How to Take Your Engineering License With You

Some engineers must practice in more than one state, and many others change jobs, moving from one part of the country to another. Depending on whether the new state has reciprocity arrangements with the old one, it is generally possible to transfer a license. How the National Council of State Boards of Engineering Examiners and National Bureau of Engineering Registration can help is explained. The requirements of various states are also described.

Abstracted from "Moving Day for Your Engineering License" by J. D. Constance, ISA Journal (Jan. 1958), 313 Sixth Ave., Pittsburgh 22, Penna.

Papers From SAE Annual Meeting, Detroit, Jan. 13-17

High-temperature Bearing Operations

Ball and roller bearings operating at high temperatures were surrounded with a reducing atmosphere to prevent destructive oxidation. Lubricating films were formed on the bearing surfaces by adding reactive compounds to the atmosphere. Research program to develop this method and determine the range of conditions where it may be usefully applied is underway.

Lubricating film-forming reaction will not proceed satisfactorily with certain metals frequently used in high-temperature bearing construction. However, bearings of all-ferrous metals do work with this method. To date test runs of 100 hr at 700 F and 22 hr at 840 F have been completed without any signs of impending bearing failure.

Abstracted from "Protective Atmosphere for High-temperature Bearing Operation," by C. H. Bailey, S. S. Sorem, A. G. Cattenreo, Shell Development Co., SAE paper 24A.

Evaluating Bearing Misalignment

Equations resulting from a test program of bearings are presented for the two basic types of misalignment (of the outer groove and of the inner groove, in relation to shaft centerline). Within these two groups, separate nomenclatures are provided for each cause of misalignment discussed. Results of the tests, on which the author's recommendations are based, are given, as well as the test method.

Abstracted from "A Method of Evaluating Bearing Misalignment," by R. S. Langdon, General Electric Co., SAE paper 17C.

High-temperature Bearing Materials

Behavior of bearings made of high-temperature materials depends not only upon bearing geometry and finish variables, but even more upon interrelation of bearing materials with lubricants. Finding satisfactory materials is up to the metallurgists, who must provide a method of screening raw materials.

Abstracted from "Discussion of Behavior of Bearings Made of High-temperature Materials," by A. S. Irwin, Marlin-Rockwell Corp., SAE paper 17D.

Principles of Noise Reduction

Five basic means of noise reduction are discussed: (1) avoiding mechanisms that produce large, impulsive forces and general refinement of design and fabrication; (2) use of mountings to reduce transmittal of disturbances; (3) damping of resonant elements to quench ringing or rumbling; (4) enclosure of noise source; (5) use of sound-absorbing materials.

Abstracted from "Principles of Noise Reduction," by L. M. Ball, Chrysler Corp., SAE paper 2A. SAE address: 485 Lexington Ave., New York 17.

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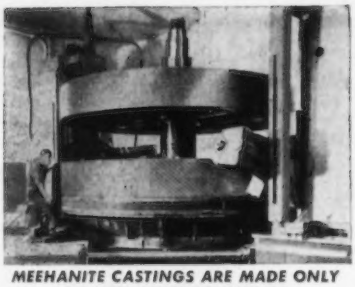

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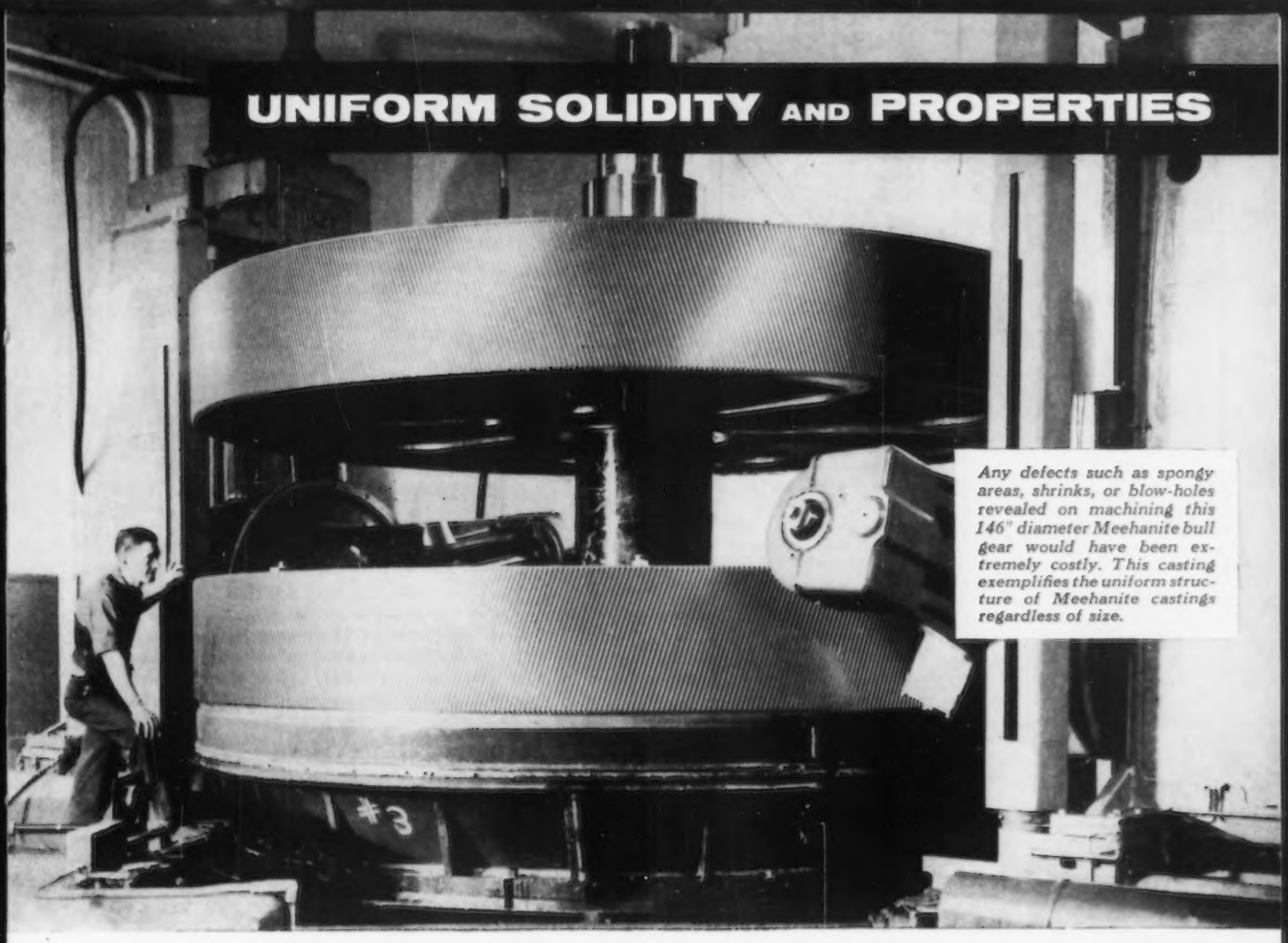

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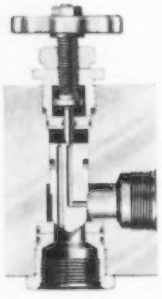

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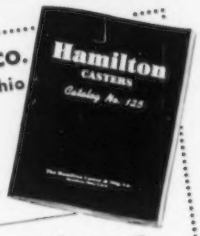

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These proceedings of a conference held under auspices of Army Ordnance at the 1955 Metal Congress and Exposition contain papers by most of the recognized experts in the field. The book covers both pure chromium and high-chrome alloys, and also contains discussions of European and Australian research. As the articles make very clear, however, chromium must be extremely pure before it exhibits any ductility; and even then its impact strength at room temperature is poor.

Pioneering in Industrial Research

KENDALL BIRR, *Associate Professor of History, New York State College for Teachers. Published by Public Affairs Press, Washington, D. C.,* 6¼x9¼, 204 *pp.* $4.50.

This is essentially an historical study of the General Electric Research Laboratory that also covers early research efforts in Europe and the U. S. There are sketches of Irving Langmuir, Willis Whitney, W. D. Coolidge, and other scientists whose personalities and ideas did much to shape the GE Research Lab. Attention is also given to research in lighting, X-rays, electronics, chemicals and metallurgy. Dr. Birr's interest is primarily that of an historian and in reviewing GE's achievements he also discusses interrelated developments in other industrial research laboratories.

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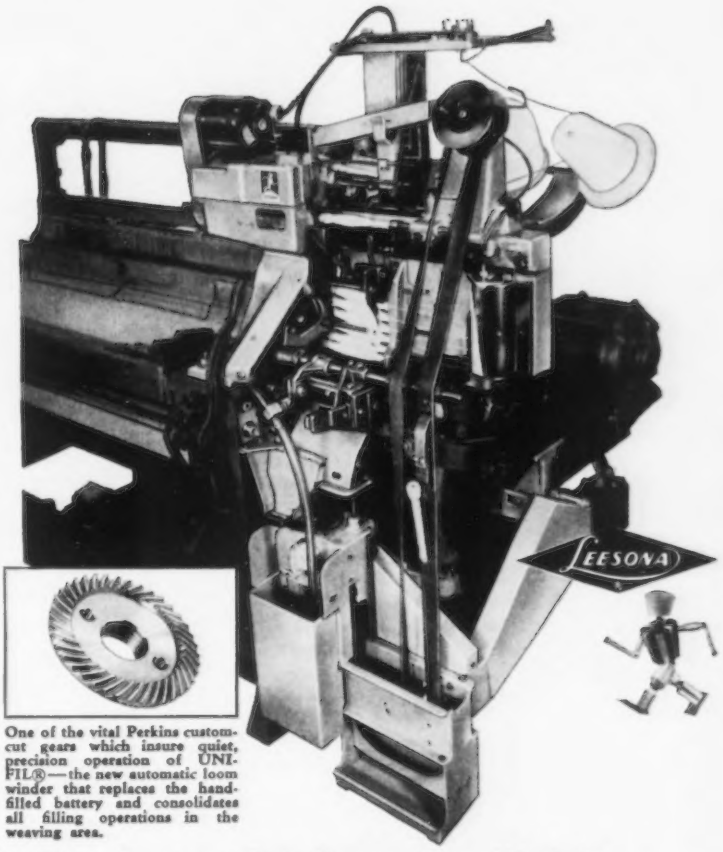

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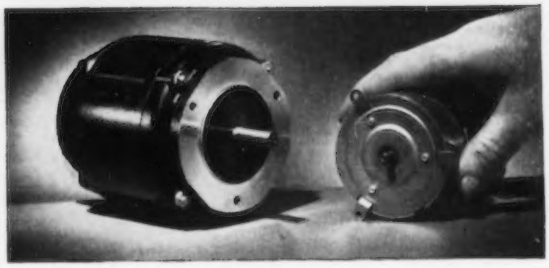

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Published by Kelly's Directories Ltd, and Iliffe & Sons Ltd., 9x6, 1,118 pp.

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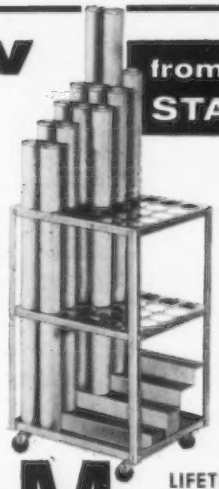

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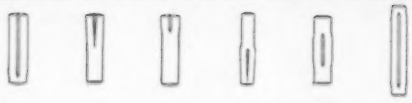

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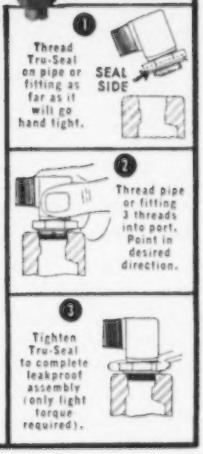
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7 Ways to Start High-inertia Loads

Mar. 3'58, p. 75. Large table analyzes relative performance of each basic method, as an aid in matching a specific load condition. Circle No. E12

Finishes for Die Castings

Mar. 3'58, p 59. Graphical guide to selection of mechanical, chemical, plating and painting methods. Circle No. E11

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Which Cantilever Beam Is Best

Feb. 17'58, p 83. Analysis discloses advantages of tapered sections; equations for four variable-section types compared with straight cantilever. Circle No. E7

Chemical Milling

Feb. 3'58, p 50. First design data on applications for this high-grade etching process for large-scale production of parts other shaping methods can't handle easily. Circle No. E6

(Continued on page 193)

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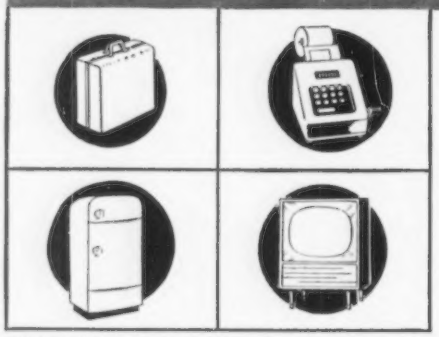

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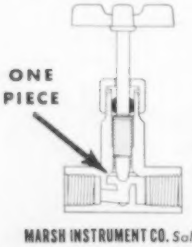

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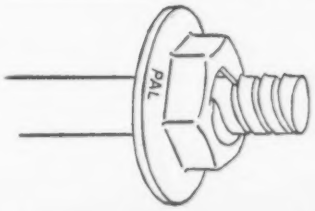

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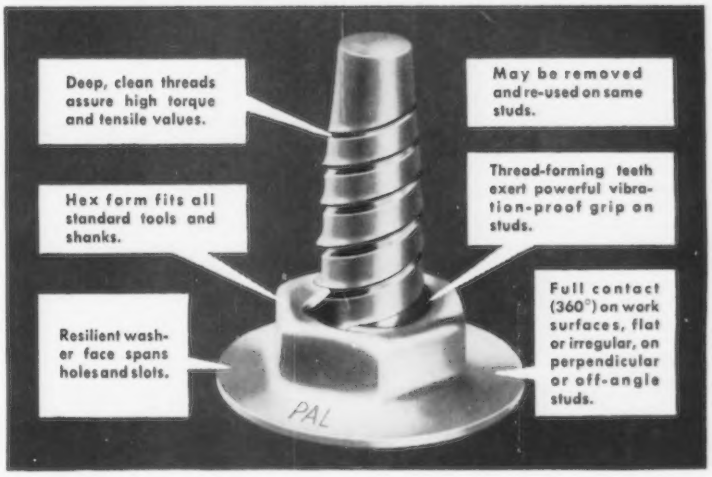
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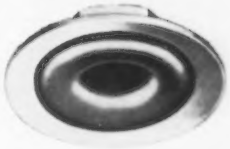

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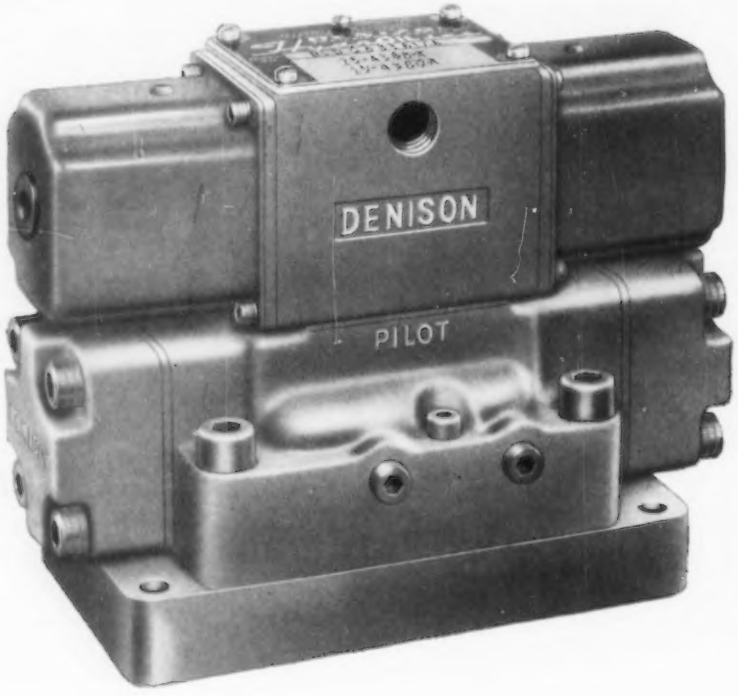

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43	44	45	46	48	50	81	84	86	88	91	93	94
95	96	97	98-9	100	101	102	103	104	105	106	107	108
109	110	111	T112	B112	113	114	115	116	117	L118	TR118	BR118
119	120-1	L122	TR122	BR122	123	L124	TR124	BR124	T125	B125	L126	TR126
BR126	127	T128	BL128	BR128	129	132	C3	C4				

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14	15	16	17	18	19	20	21	22	23	24	25	26
27	28	29	30	31	32	33	34	35	36	37	38	39
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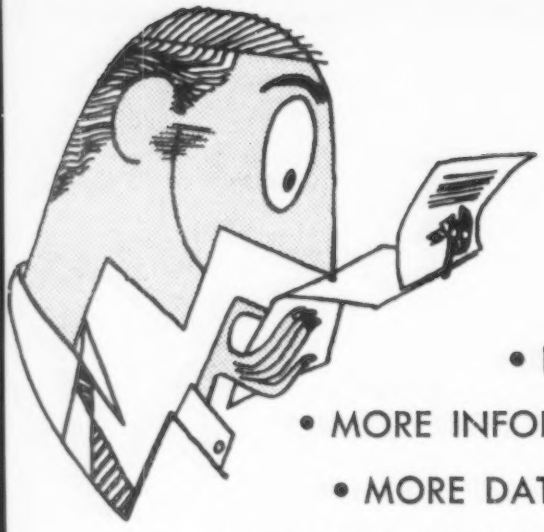

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We *make* a lot of Gearmotors here at Master. The point is, we've been *selling* more than all other makes combined. There are more Master Gearmotors in *use* than all others. Users *buy* more. And you don't find any foolish motor buyers—or not for long.

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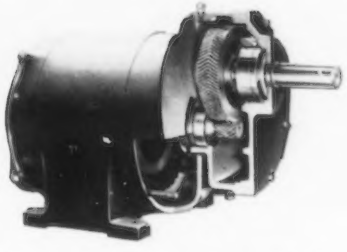

Master Gearmotors are available with all Master motor types in right angle and parallel construction.

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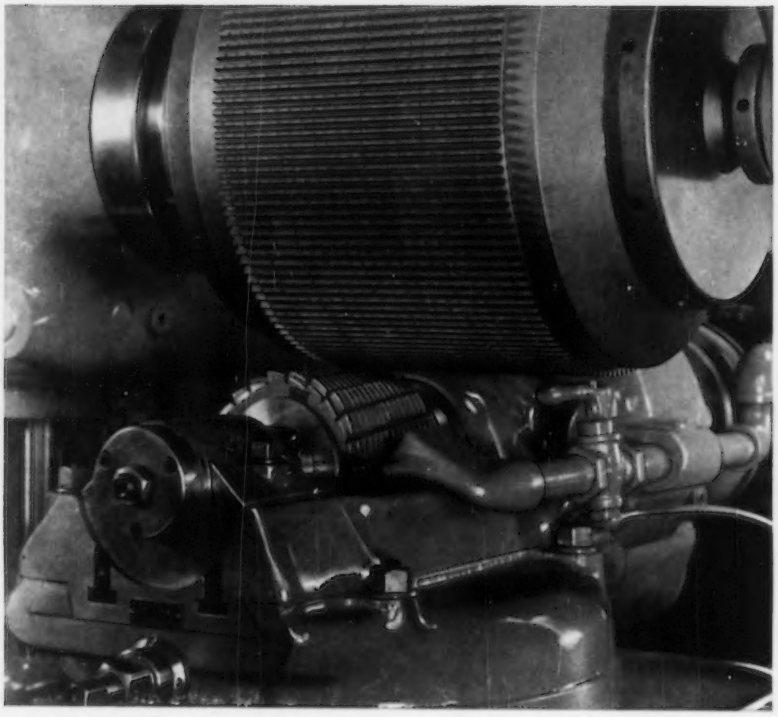
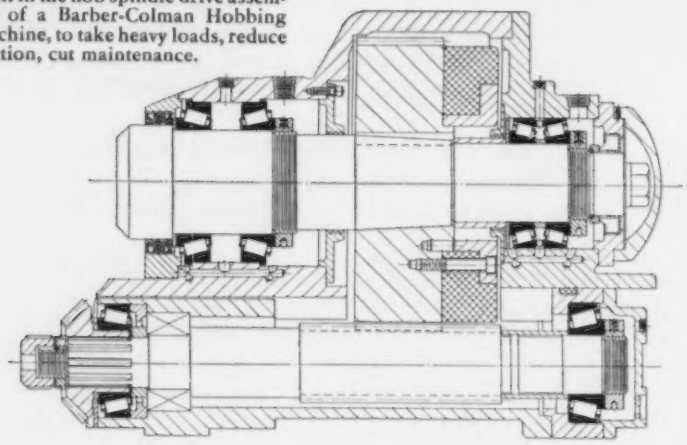
Hobs at speeds of 300 SFM —TIMKEN® bearings shrug off heavy loads



TYPICAL Timken bearing arrangement in the hob spindle drive assembly of a Barber-Colman Hobbing Machine, to take heavy loads, reduce friction, cut maintenance.



TO take the heavy loads and minimize friction when hobbing steel gears at high speeds—up to 300 SFM—Barber-Colman uses Timken® tapered roller bearings at vital points in its No. 14-15 Hydraulic Hobbing Machine. The high speed hob slide has a hob spindle mounted in Timken bearings. They're also used in the hob drive and for the top bearing on the index worm shaft. Result—gear production is faster, more accurate. Tool life is increased.

SHRUG OFF HEAVY LOADS. Timken bearing rollers and races are case-carburized to have a hard, wear-resistant surface over a tough, shock-resistant core. They take heavy loads with no trouble at all.

KEEP SPINDLE RIGID. Timken bearings hold the spindle in positive alignment. Their tapered design lets them take *both* radial and thrust loads in any combination. And they have extra load-carrying capacity because of full line contact between rollers and races.

PRACTICALLY ELIMINATE FRICTION. Geometrically designed to roll true, Timken bearings are precision-made to live up to their design. They run longer, smoother, cooler.

And for extra quality control, we even make our own electric furnace fine alloy steel. No other American bearing maker does. To get your No. 1 bearing value, always get bearings carrying the trade-mark "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

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TAPERED ROLLER BEARINGS ROLL THE LOAD